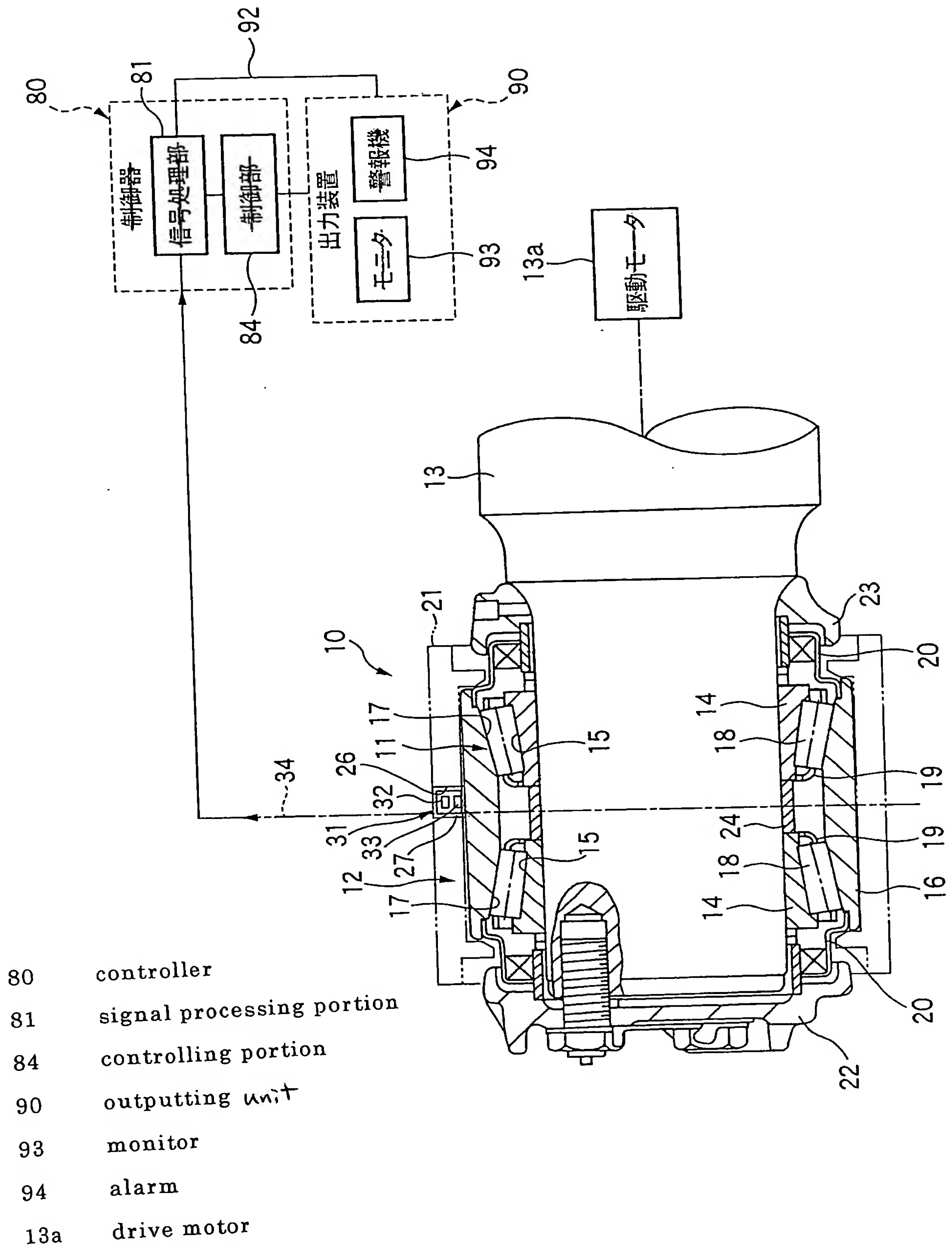
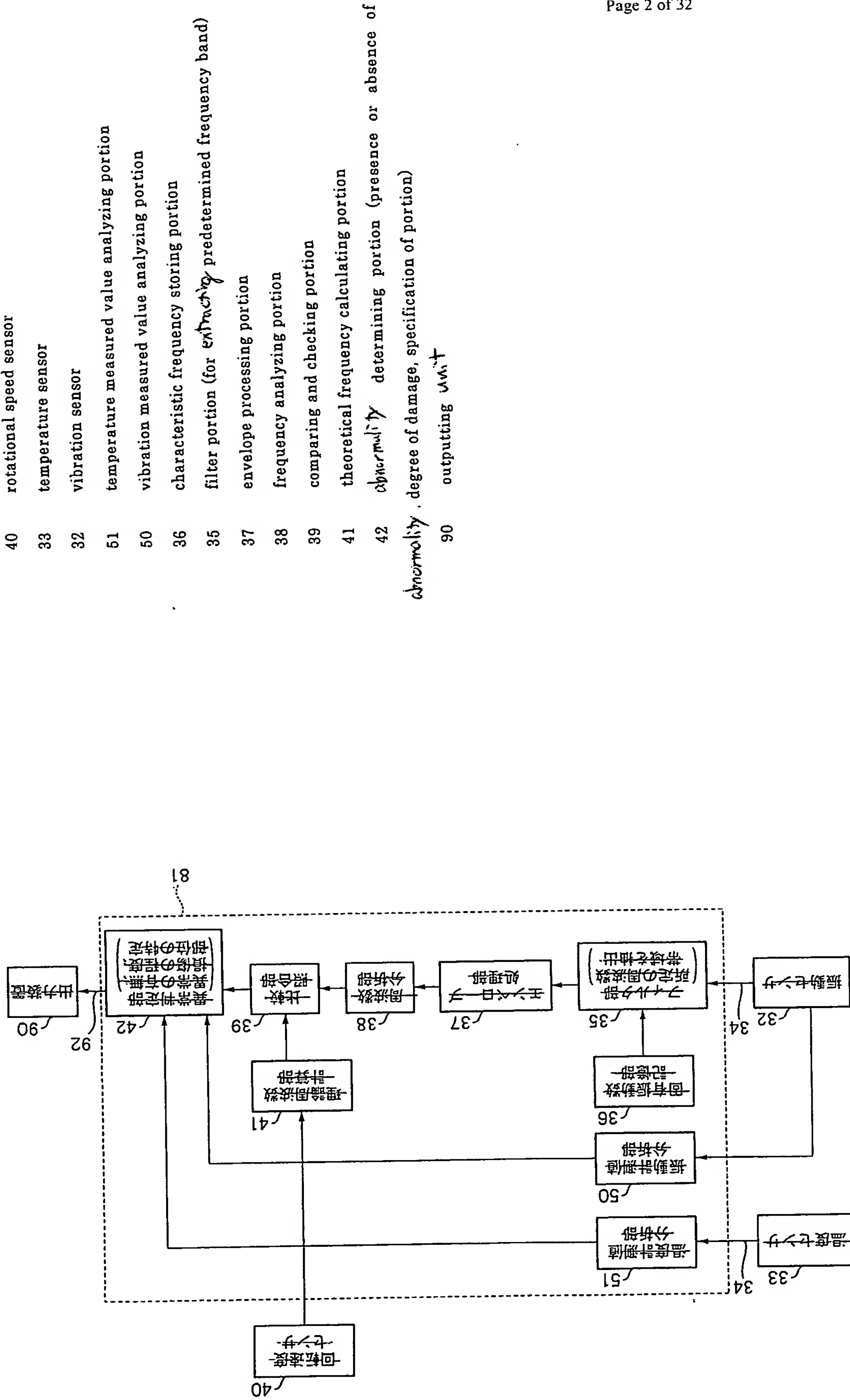


[図1] Fig. 1



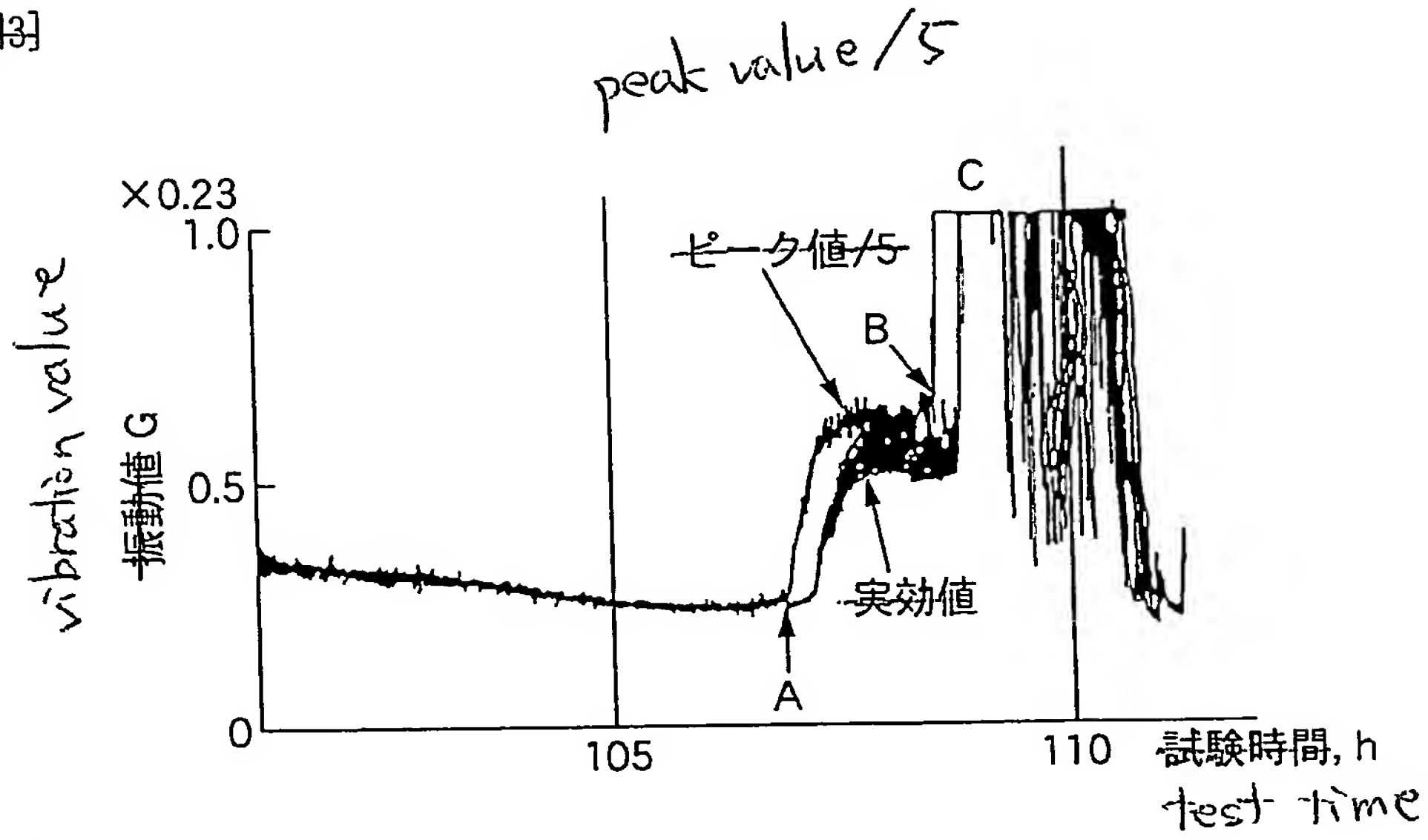
[Fig. 2]



40 rotational speed sensor
33 temperature sensor
32 vibration sensor
51 temperature measured value analyzing portion
50 vibration measured value analyzing portion
36 characteristic frequency storing portion
35 filter portion (for ~~extracting~~ predetermined frequency band)
37 envelope processing portion
38 frequency analyzing portion
39 comparing and checking portion
41 theoretical frequency calculating portion
42 ~~abnormality~~ determining portion (presence or absence of
abnormality, degree of damage, specification of portion)
90 outputting unit

Fig. 3

[図3]



[図4]

Fig. 4

temperature at outer diameter
surface of outer ring

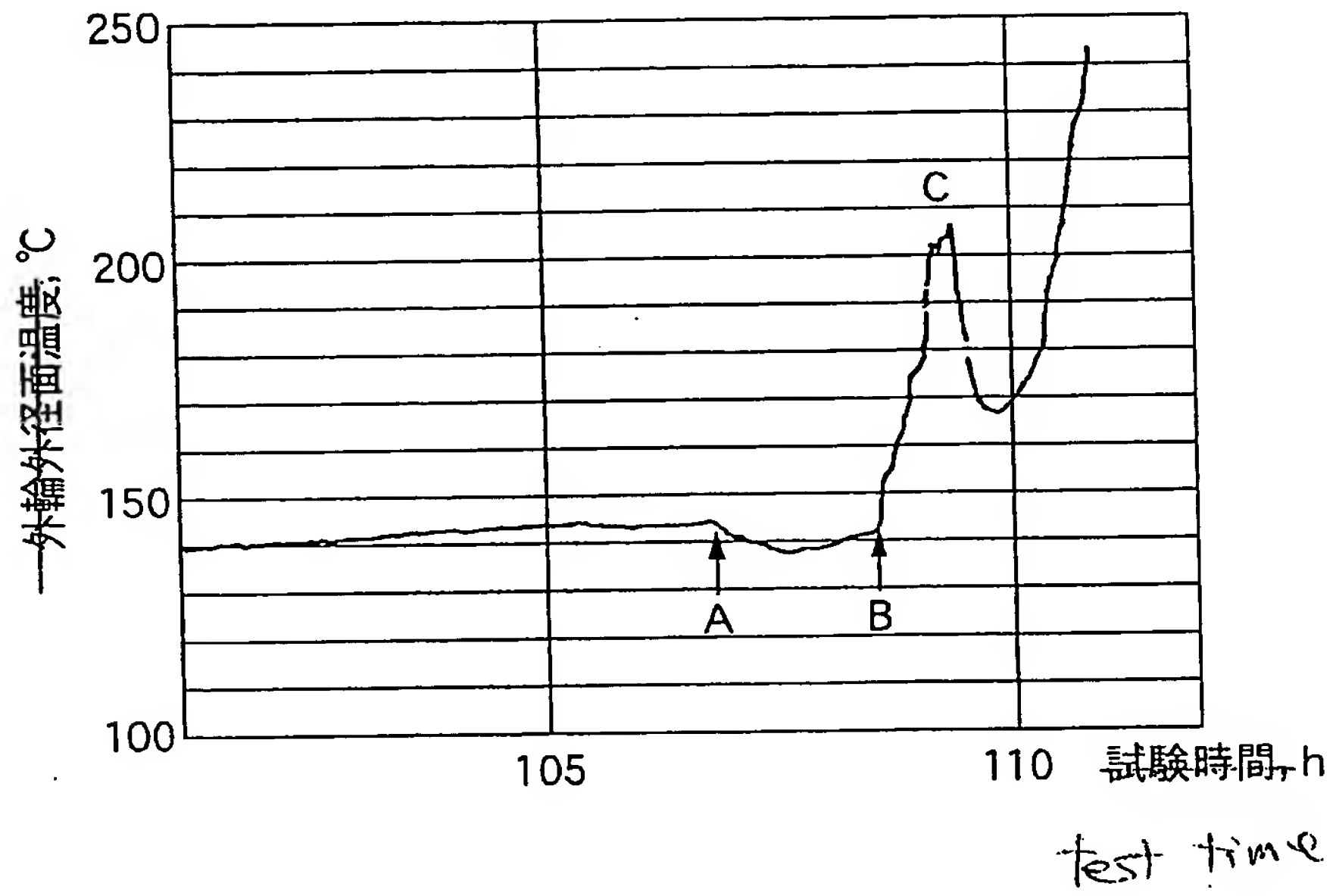


Fig. 5
 [図5]

軸受の部位 (Sx) portion of bearing	部位に対応する周波数 frequency corresponding to the portion
内輪 (Si) inner ring	$Zf_i = \frac{f_r}{2} \left(1 + \frac{D_a}{d_m} \cdot \cos \alpha \right) Z$
外輪 (So) outer ring	$Zf_o = \frac{f_r}{2} \left(1 - \frac{D_a}{d_m} \cdot \cos \alpha \right) Z$
転動体 (Sb) rolling element	$2f_b = f_r \left(1 - \frac{D_a^2}{d_m^2} \cdot \cos^2 \alpha \right) \frac{d_m}{D_a}$
保持器 (Sc) retainer	$f_c = \frac{f_r}{2} \left(1 - \frac{D_a \cdot \cos \alpha}{d_m} \right)$

f_r : 内輪(外輪)回転速度 [Hz] Z : 転動体の数
 f_c : 保持器回転速度 [Hz] f_i : $f_r - f_c$
 f_b : 転動体自転速度 [Hz] D_a : 転動体直径 [mm]
 d_m : 転動体ピッチ円径 [mm] α : 接触角 [rad]

f_r : inner (outer) ring rotational speed [Hz]

f_c : retainer rotational speed [Hz]

f_b : rolling member rotating speed [Hz]

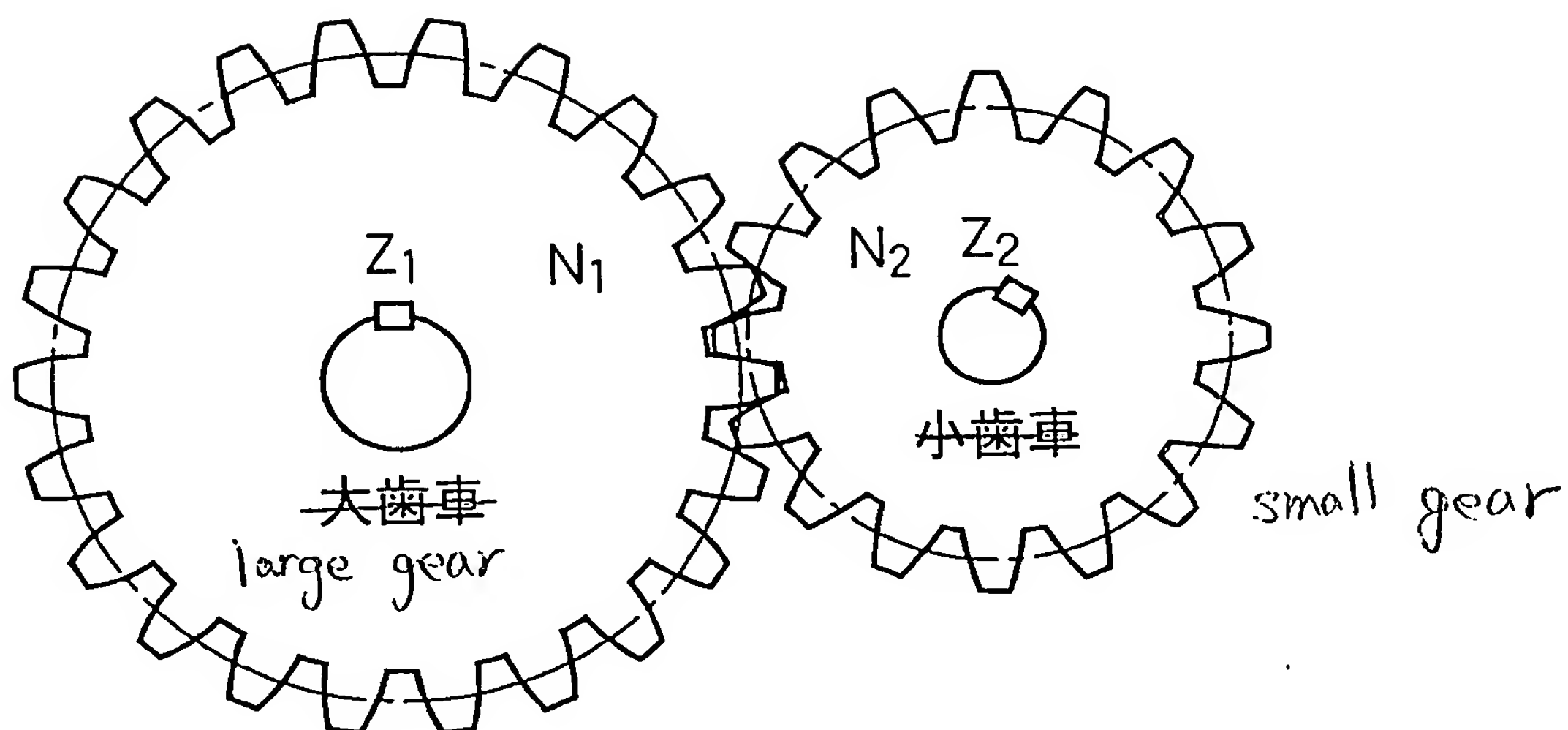
d_m : rolling element pitch circle diameter [mm]

Z : number of rolling element

D_a : rolling member diameter [mm]

α : contact angle [rad]

Fig. 6
 [図6]



かみ合い周波数成分: $Sg = Z_1 \times \frac{N_1}{60}$ or $Sg = Z_2 \times \frac{N_2}{60}$
 mesh frequency component

N_1 : 大歯車の回転数(min⁻¹)

N_2 : 小歯車の回転数(min⁻¹)

Z_1 : 大歯車の歯数

Z_2 : 小歯車の歯数

N_1 : rotational speed of large gear (min⁻¹)

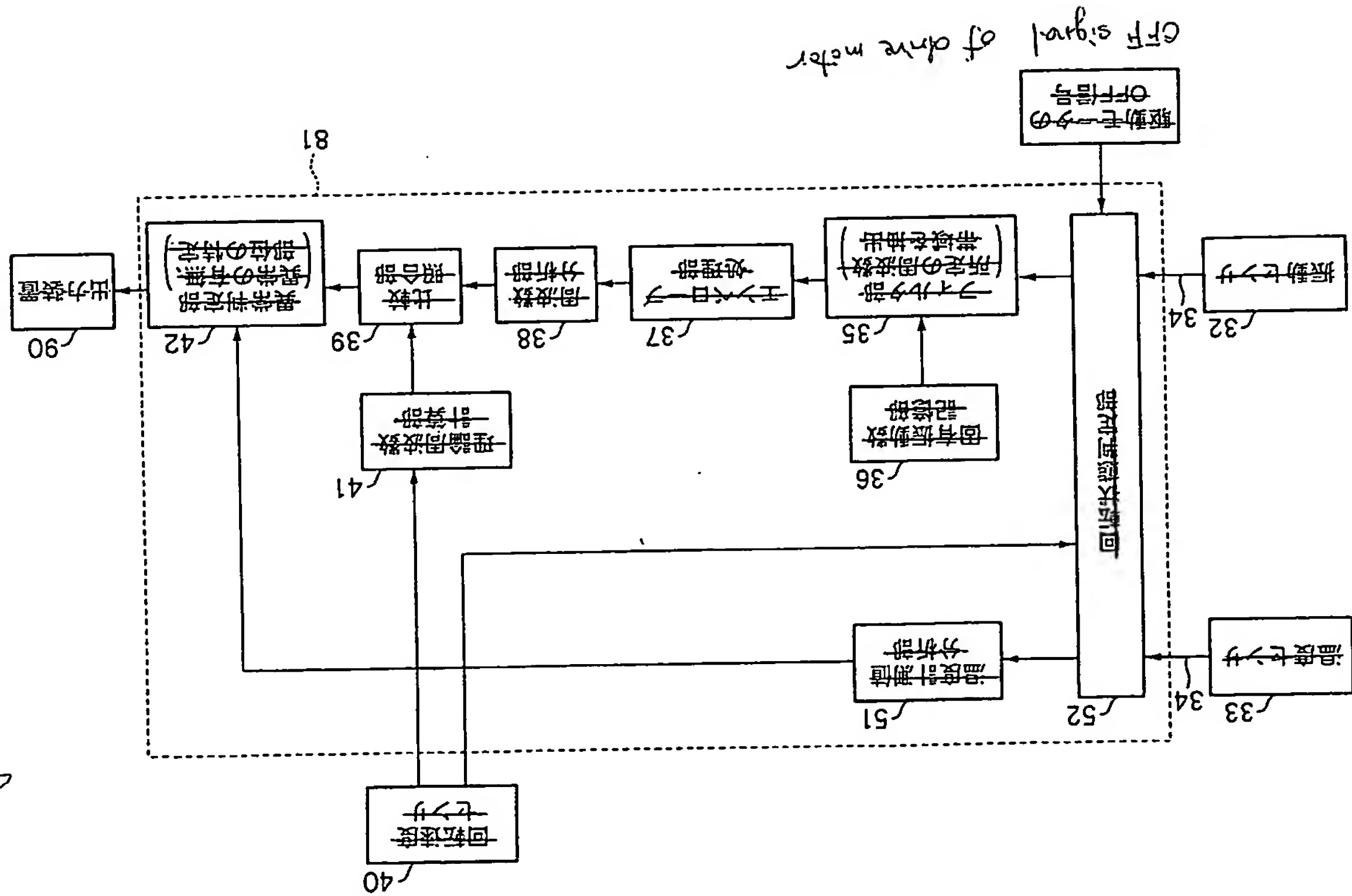
N_2 : rotational speed of small gear (min⁻¹)

Z_1 : teeth number of large gear

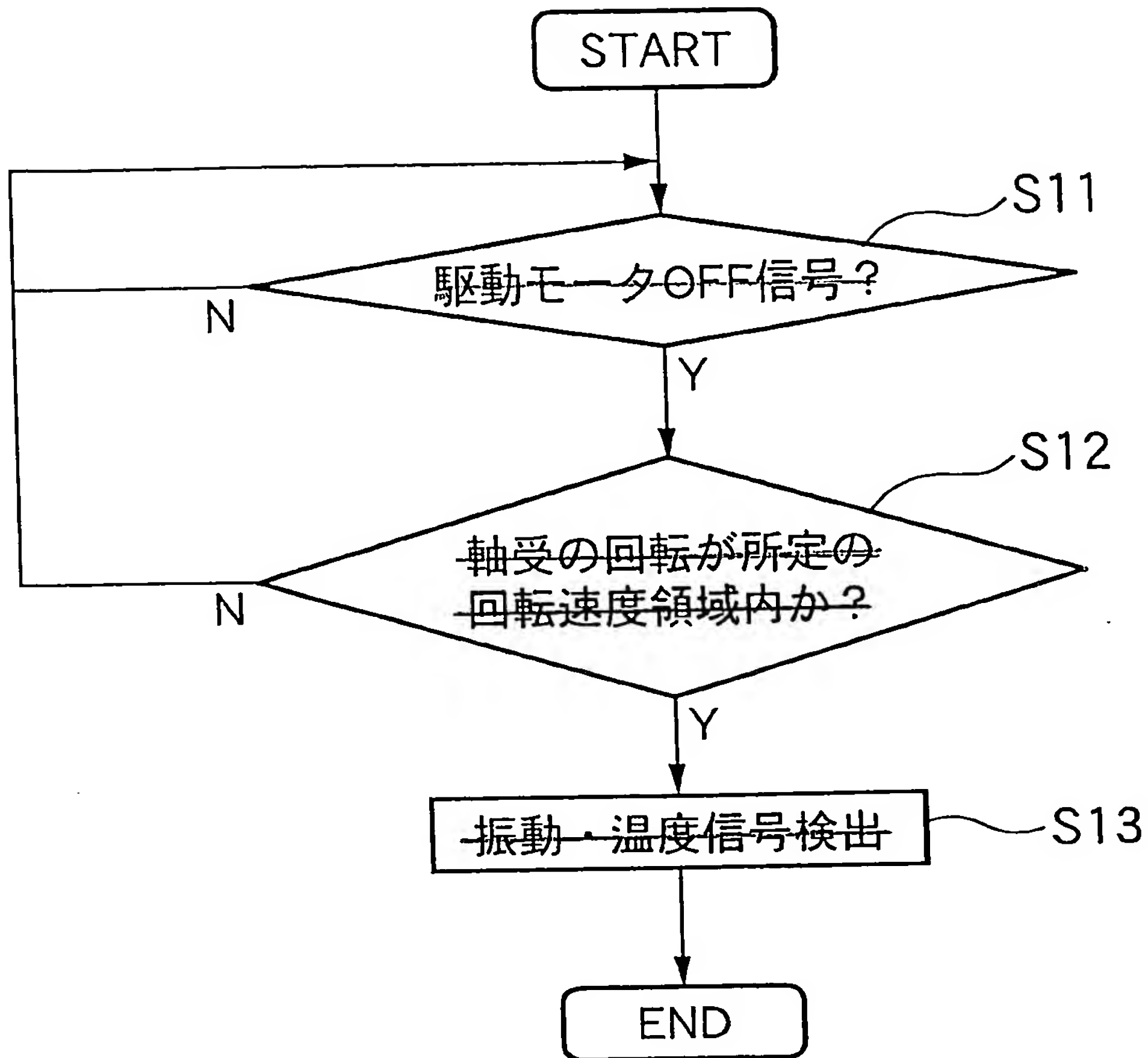
Z_2 : teeth number of small gear

[Fig. 7]

- 33 temperature sensor
- 32 vibration sensor
- 52 rotational state determining portion
- 51 temperature measured value analyzing portion
- 36 characteristic frequency storing portion
- 35 filter portion (for extracting predetermined frequency band)
- 37 envelope processing portion
- 38 frequency analyzing portion
- 40 rotational speed sensor
- 41 theoretical frequency calculating portion
- 39 comparing and checking portion
- 42 abnormality determining portion (for specifying presence or absence of abnormality, degree of damage, specification of portion)
- 90 outputting unit



[図8] Fig. 8

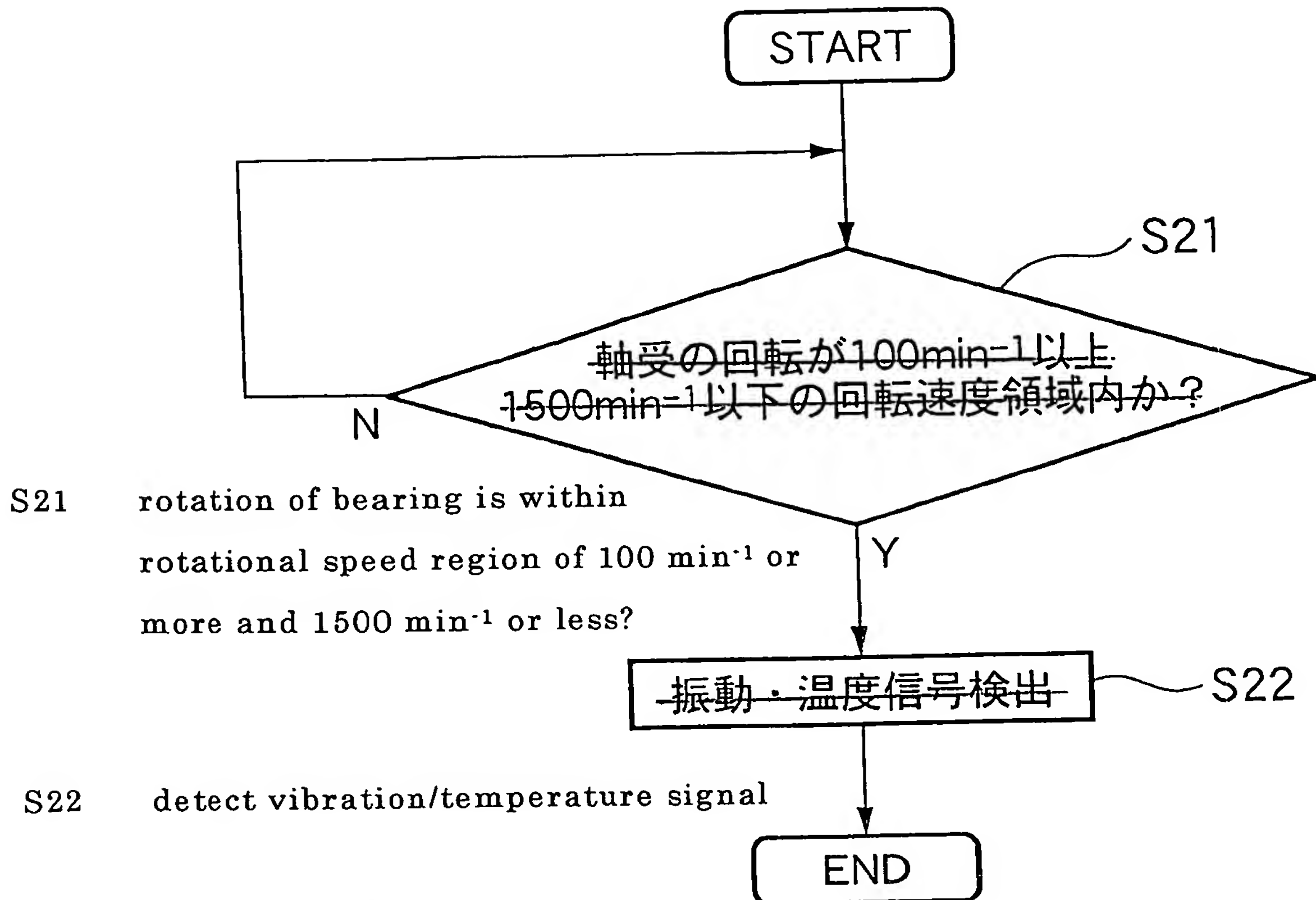


S11 drive motor OFF signal?

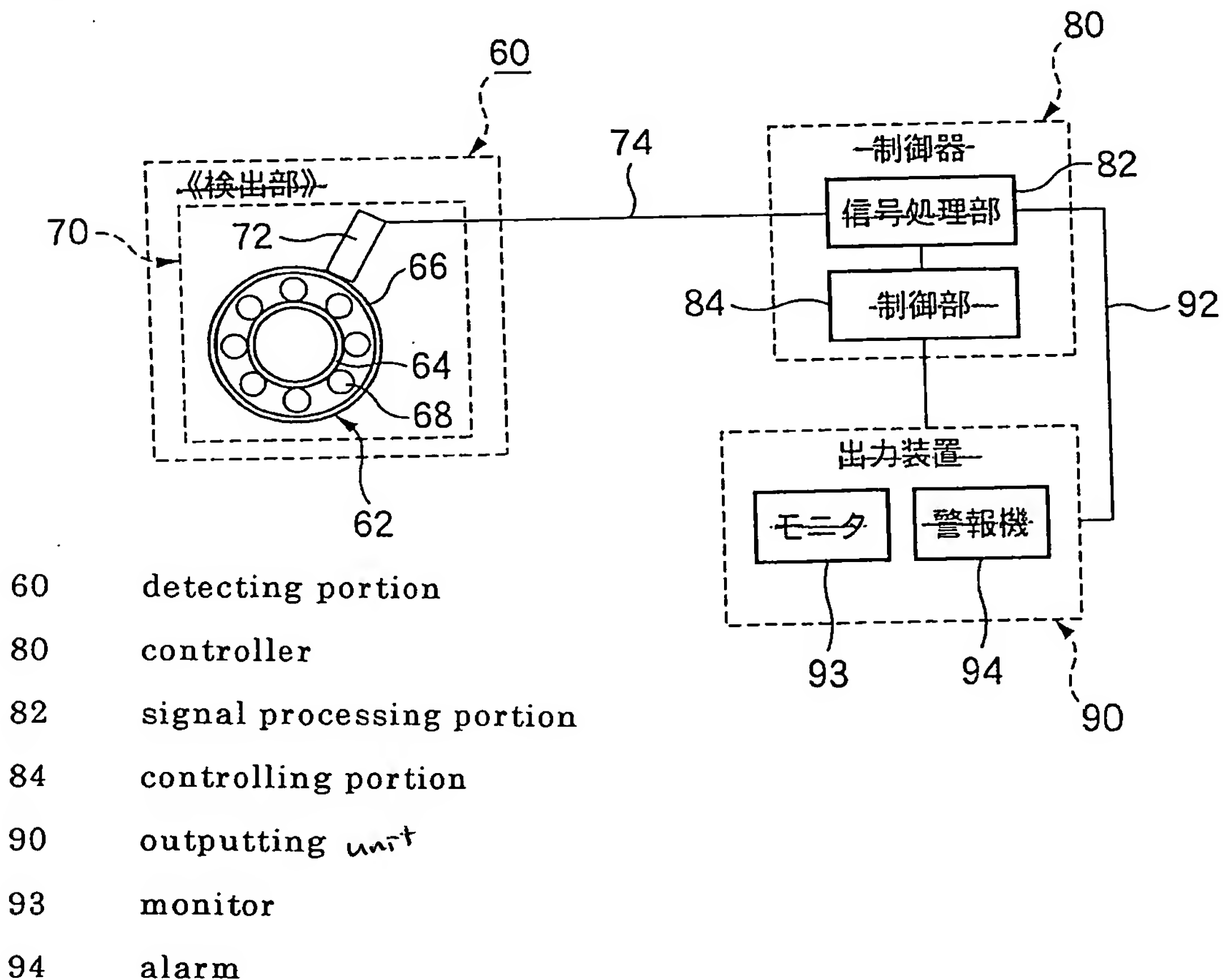
S12 rotation bearing is within predetermined rotational speed region?

S13 detect vibration/temperature signal

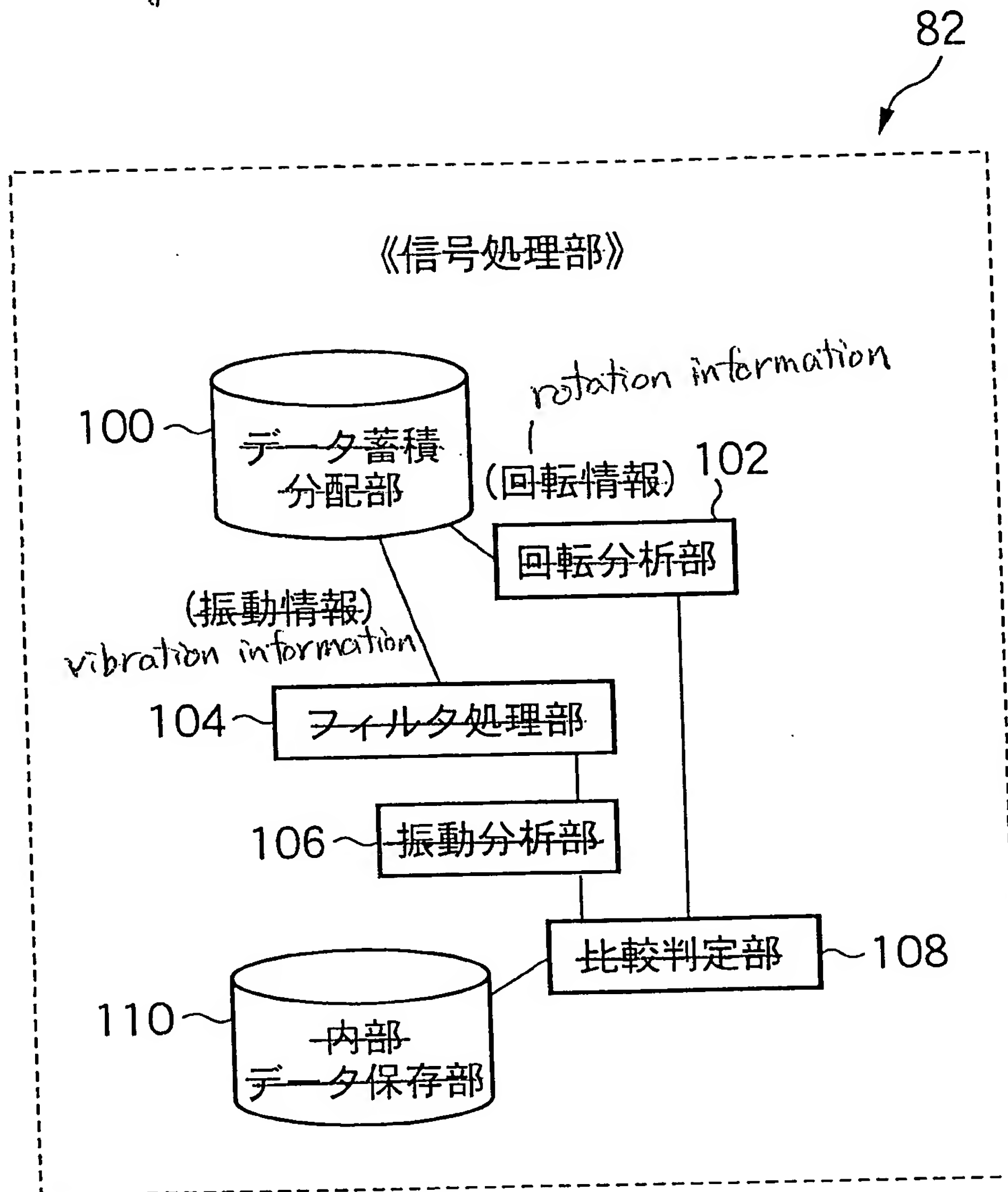
[図9] Fig. 9



[図10] Fig. 10

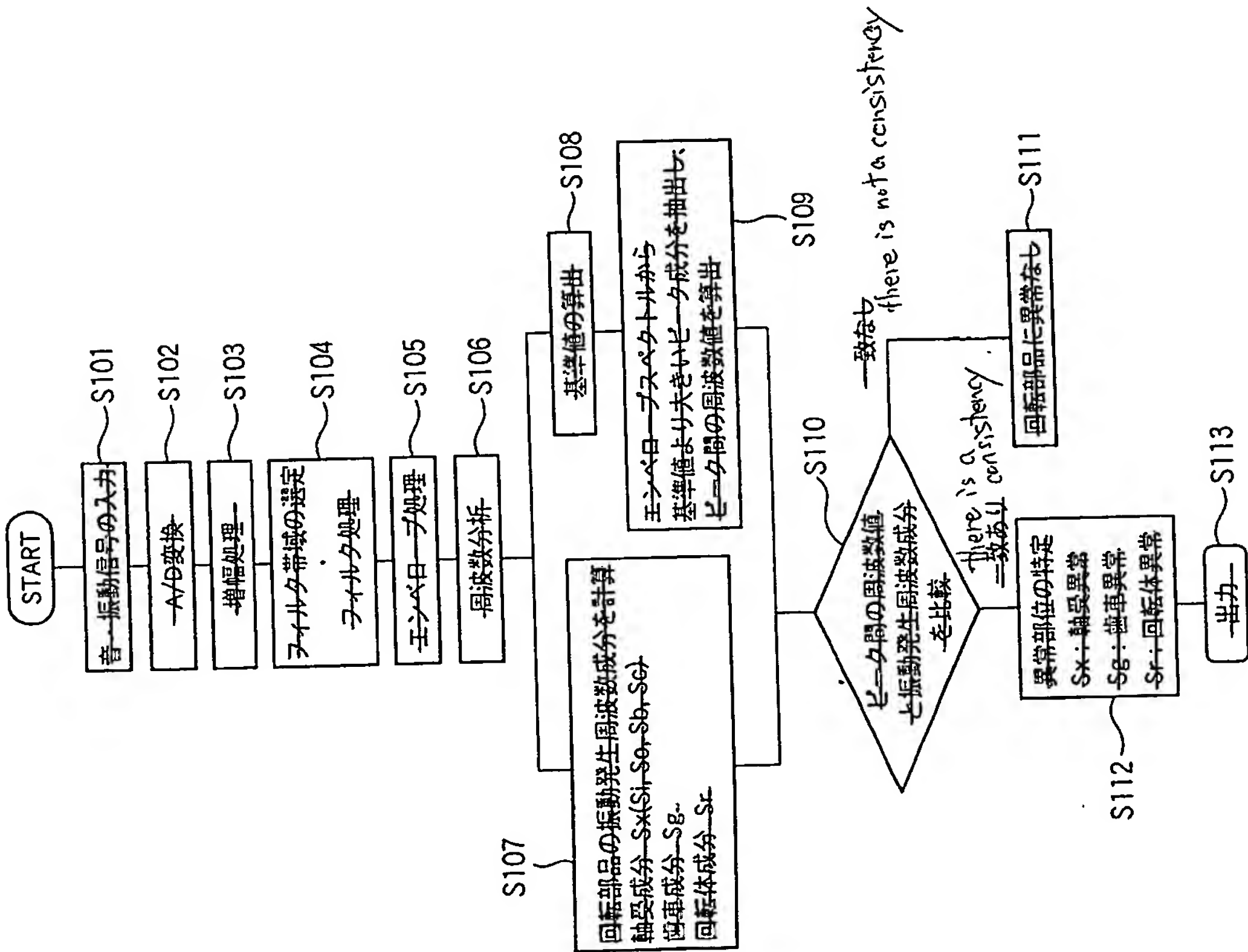


[図11] Fig. 11



- | | |
|-----|--|
| 82 | signal processing portion |
| 100 | data accumulating and distributing portion |
| 102 | rotation analyzing portion |
| 104 | filter processing portion |
| 106 | vibration analyzing portion |
| 108 | comparing and determining portion |
| 110 | internal data holding portion |

Fig. 12



[Fig. 12]

- S101 input sound/vibration signal
- S102 A/D conversion
- S103 amplifying processing
- S104 select filter band and filter processing
- S105 envelope processing
- S106 frequency analysis
- S107 calculate vibration generating frequency component of rotating part
- bearing component Sx (Si, So, Sb, Sc)
- gear component Sg
- rotating member component Sr
- S108 calculate reference value
- S109 sample peak component larger than reference value from envelope spectrum and calculate frequency value between peaks
- S110 compare frequency value between peaks and vibration generating frequency component
- S111 rotating member is not abnormal
- S112 specify abnormal portion
- Sx: bearing abnormal
- Sg: gear abnormal
- Sr: rotating member abnormal
- S113 output

図13
Fig. 13

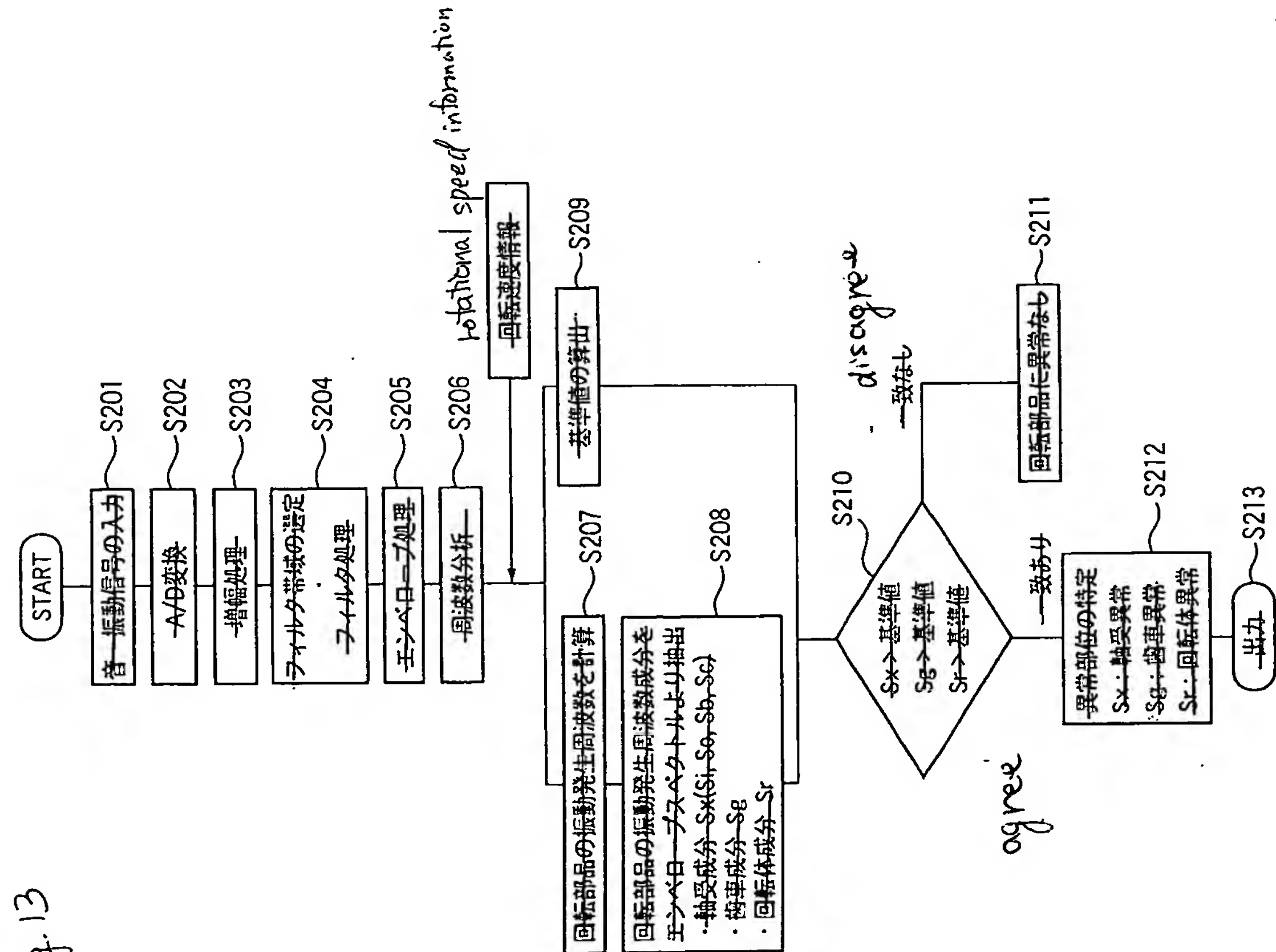
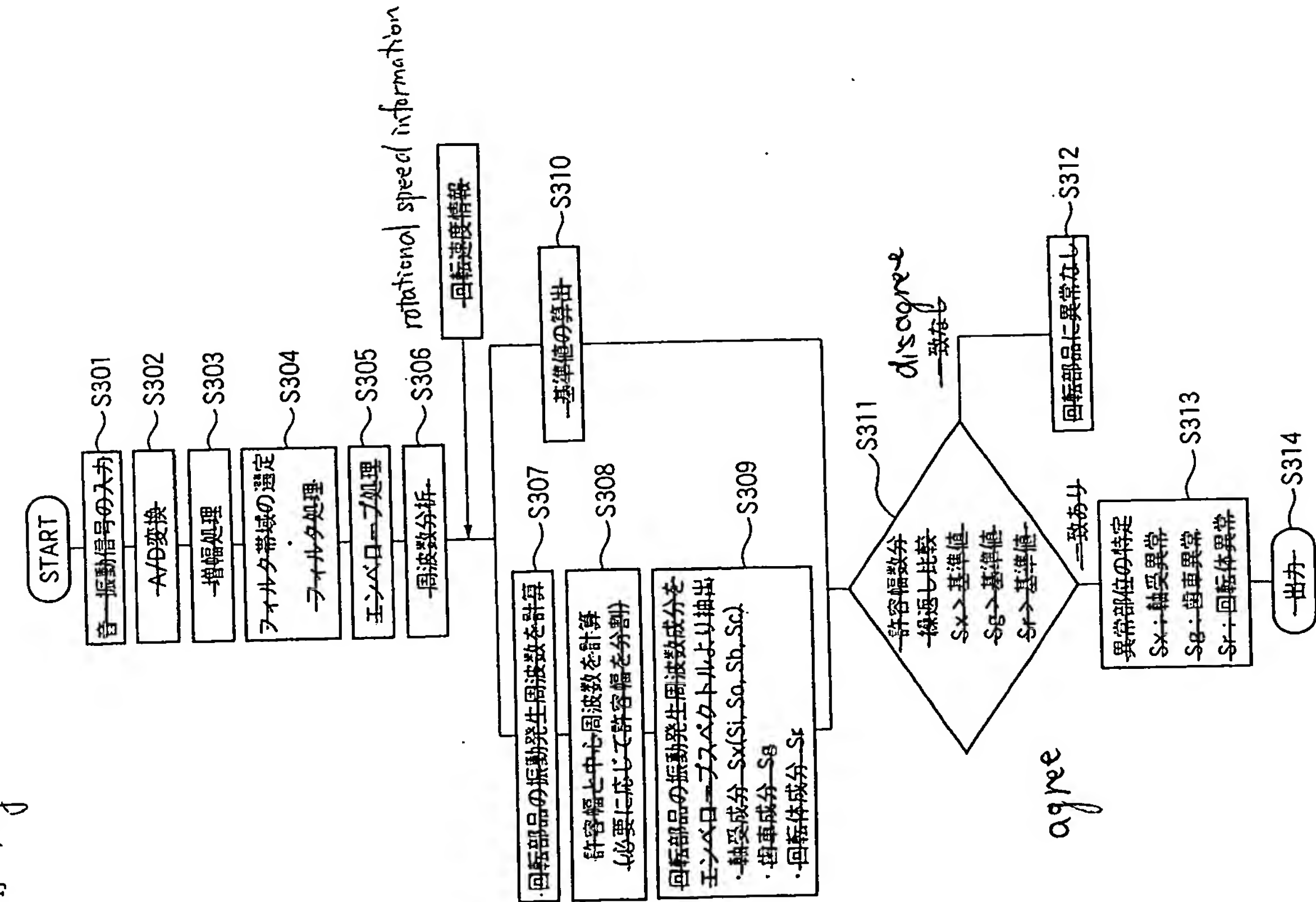


Fig.13

- S201 input sound/vibration signal
- S202 A/D conversion
- S203 amplifying processing
- S204 select filter band and filter processing
- S205 envelope processing
- S206 frequency analysis
- S207 calculate vibration generating frequency of rotating part
- S208 sample vibration generating frequency component of rotating part from envelope spectrum
- ・ bearing component Sx (Si, So, Sb, Sc)
 - ・ gear component Sg
 - ・ rotating member component Sr
- S209 calculate reference value
- S210 Sx > reference value
Sg > reference value
Sr > reference value
- coincidence
- no coincidence
- S211 rotating member is not abnormal
- S112 specify abnormal portion
- Sx: bearing abnormal
- Sg: gear abnormal
- Sr: rotating member abnormal
- S113 output

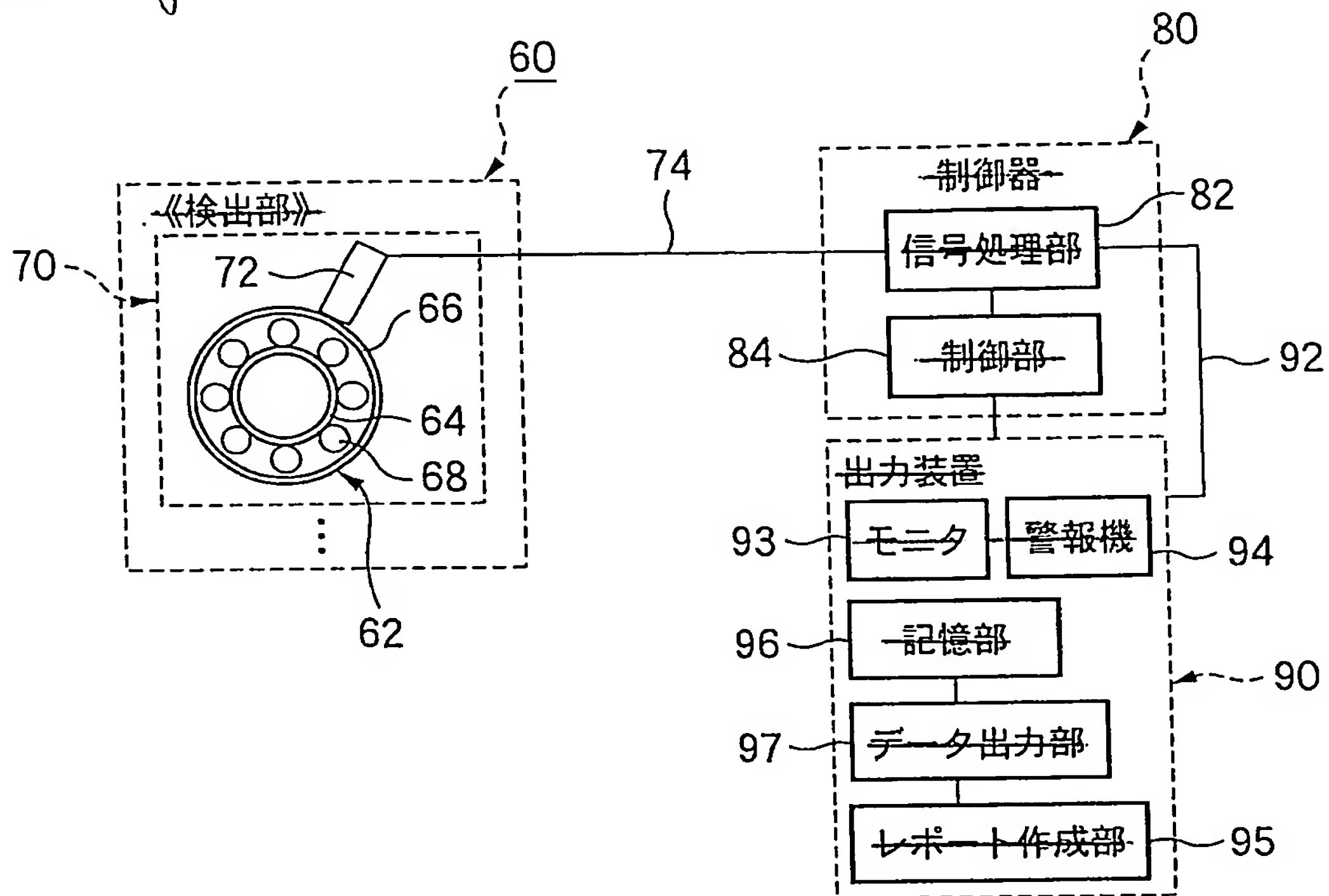
図14 Fig. 14



[Fig. 14]

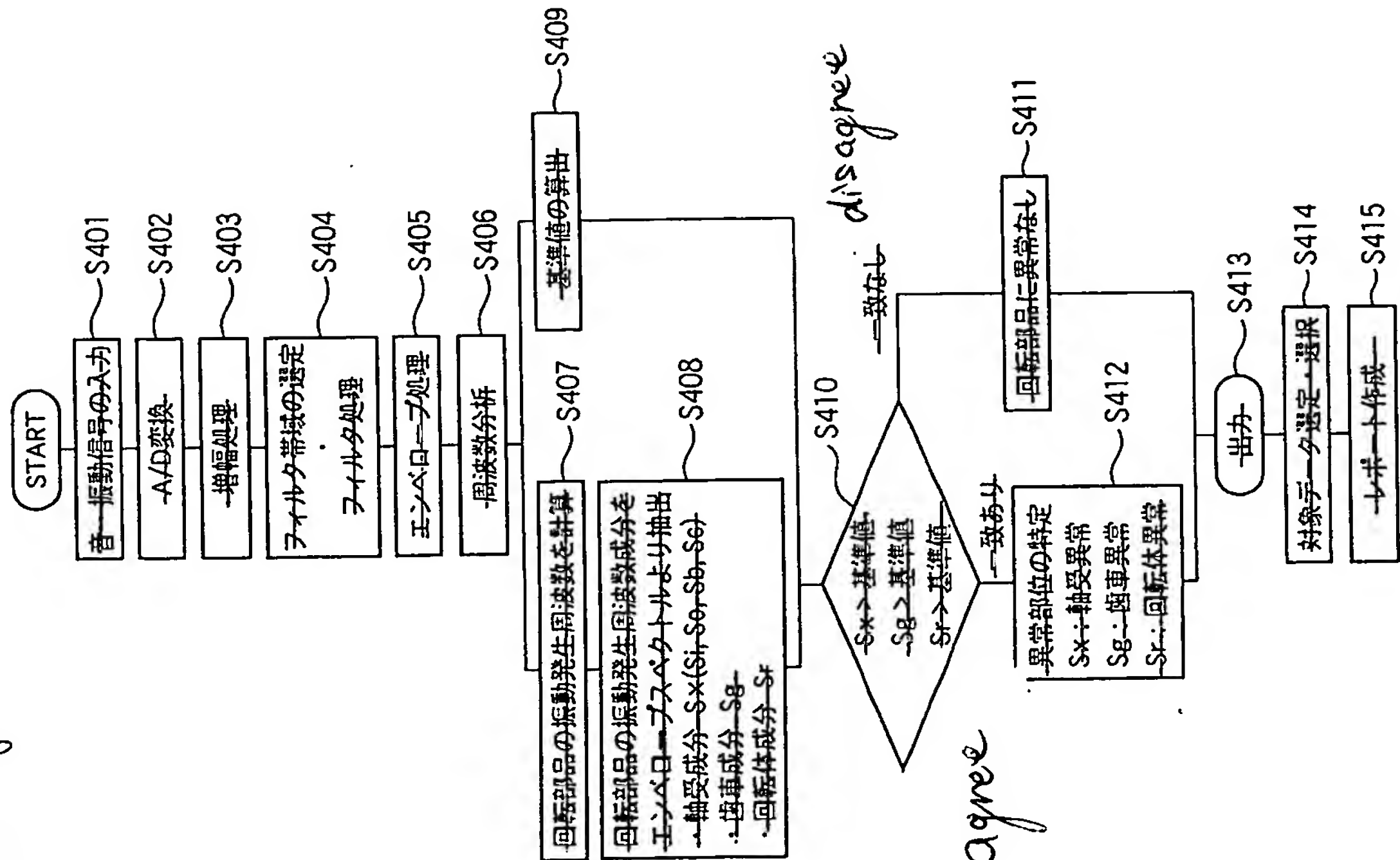
- S301 input sound/vibration signal
- S302 A/D conversion
- S303 amplifying processing
- S304 select filter band and filter processing
- S305 envelope processing
- S306 frequency analysis
- S307 calculate vibration generating frequency of rotating part
- S308 calculate allowable width and central frequency (divide allowable width as necessary)
- S309 sample vibration generating frequency component of rotating part from envelope spectrum
- bearing component Sx (Si, So, Sb, Sc)
- gear component Sg
- rotating member component Sr
- S310 calculate reference value
- S311 repeatedly compare amount of allowable width number
- Sx > reference value
- Sg > reference value
- Sr > reference value
- S312 rotating member is not abnormal
- S313 specify abnormal portion
- Sx: bearing abnormal
- Sg: gear abnormal
- Sr: rotating member abnormal
- S314 output

[図15] Fig. 15



- 60 detecting portion
- 80 controller
- 82 signal processing portion
- 84 controlling portion
- 90 outputting unit
- 93 monitor
- 94 alarm
- 96 storing portion
- 97 data outputting portion
- 95 report forming portion

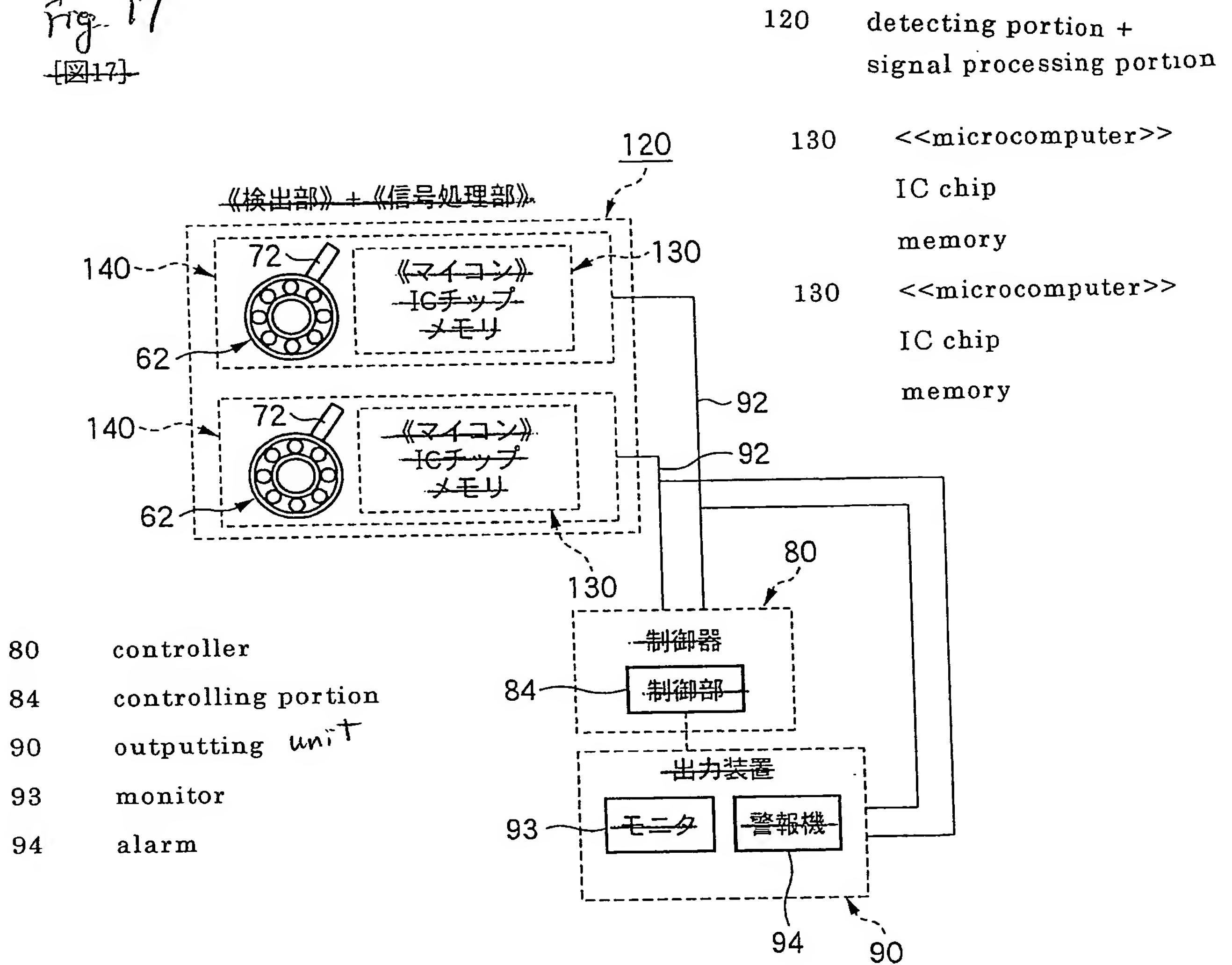
Fig. 16



[Fig. 16]

- S401 input sound/vibration signal
S402 A/D conversion
S403 amplifying processing
S404 select filter band and filter processing
S405 envelope processing
S406 frequency analysis
S407 calculate vibration generating frequency of rotating part
S408 ~~sample~~ vibration generating frequency component of rotating part from envelope specter
· bearing component Sx (Si, So, Sb, Sc)
· gear component Sg
· rotating member component Sr
S409 calculate reference value
S410 Sx > reference value
Sg > reference value
Sr > reference value
S411 rotating part is not abnormal
S412 specify abnormal portion
Sx: bearing abnormal
Sg: gear abnormal
Sr: rotating member abnormal
S413 output
S414 select object data
S415 form report

Fig. 17
 [図17]



[図18]

Fig. 18

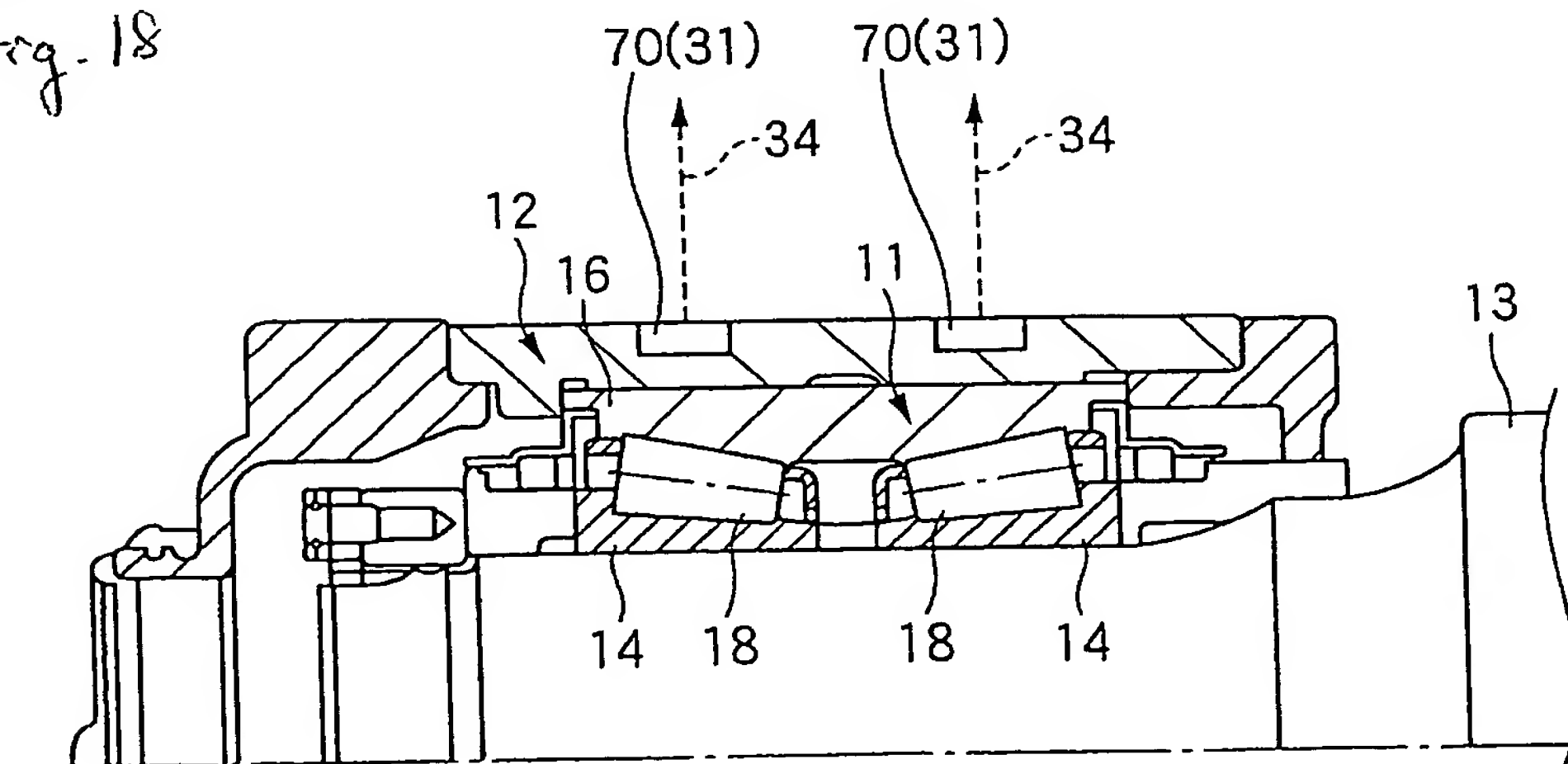
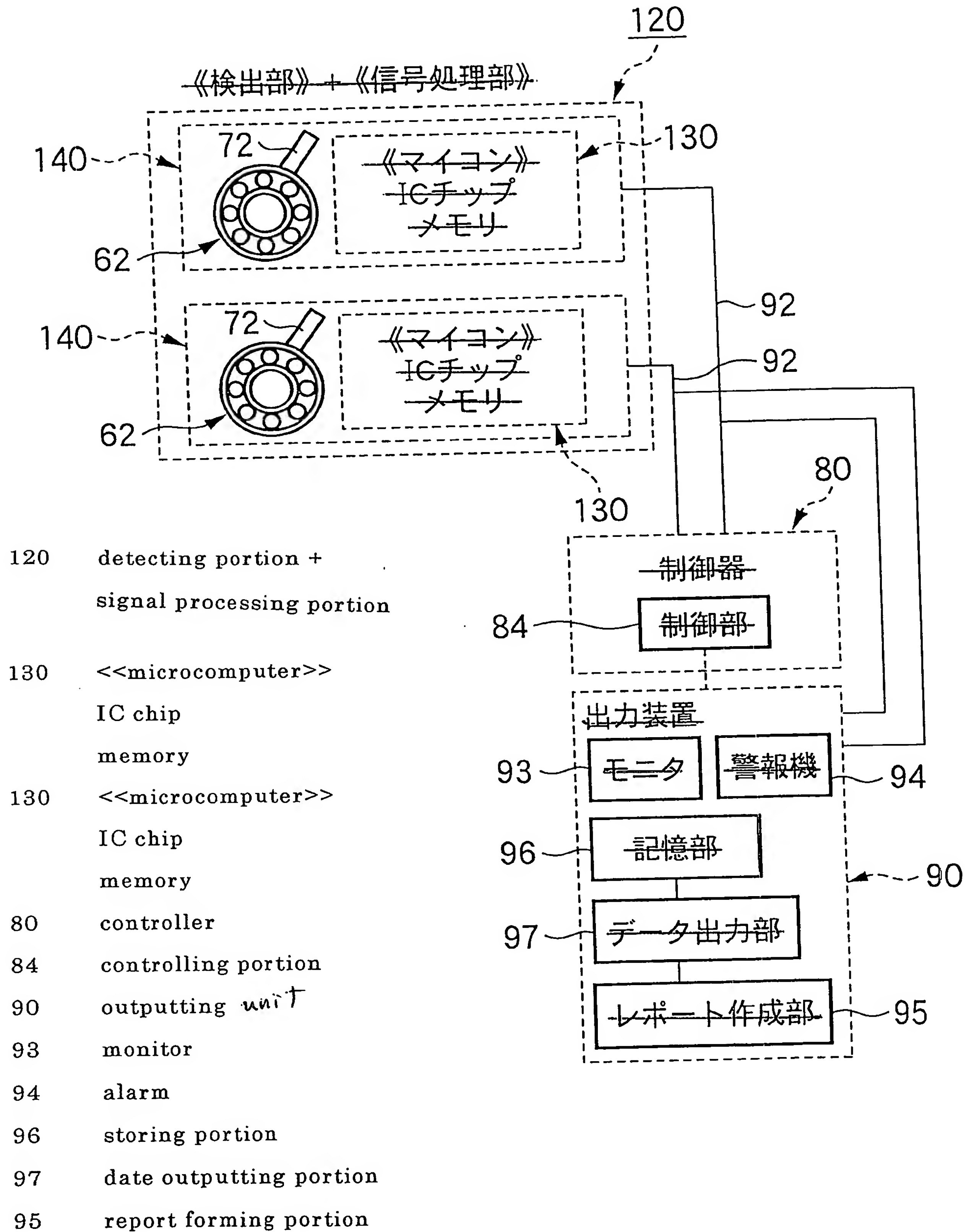
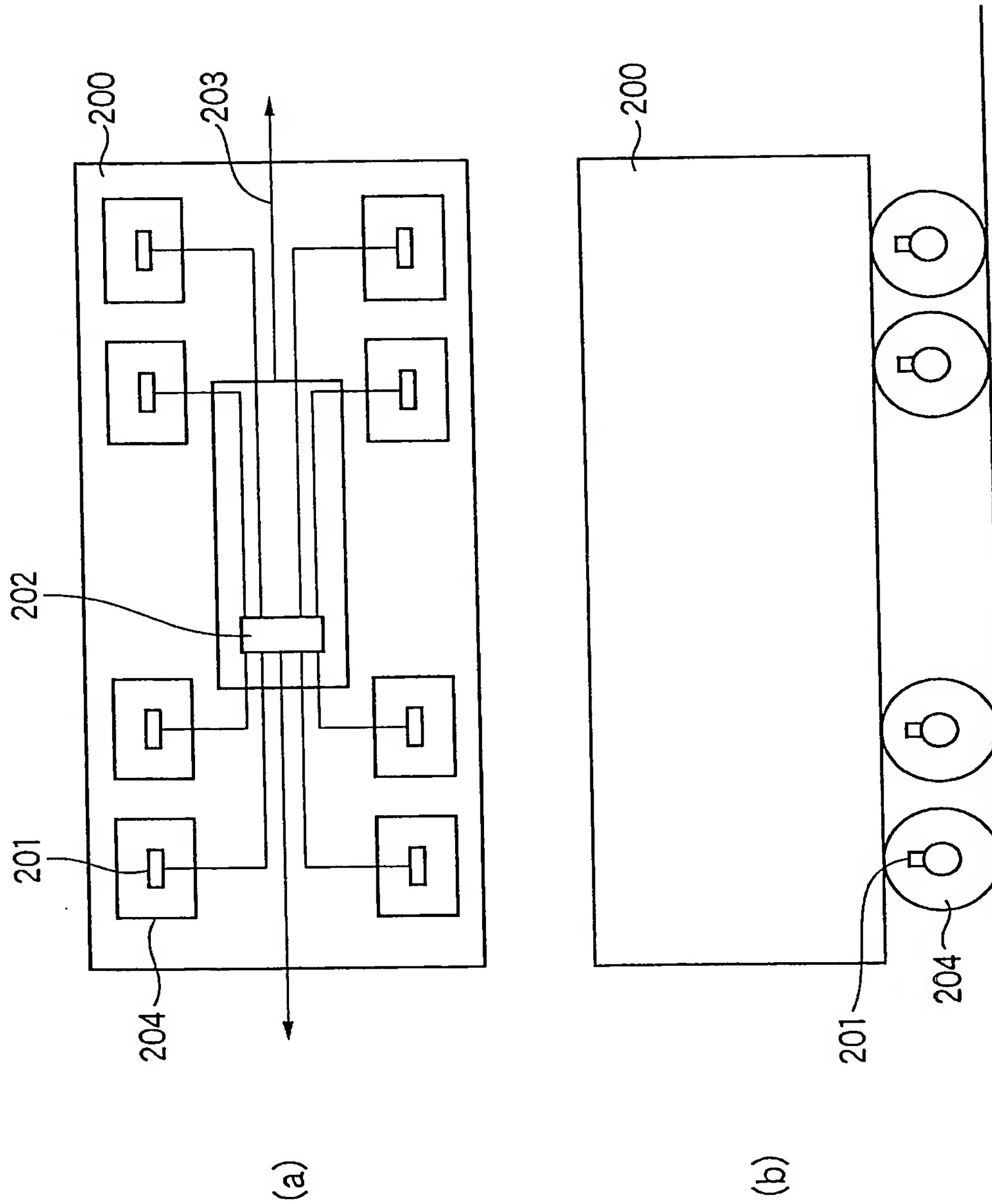


Fig. 19

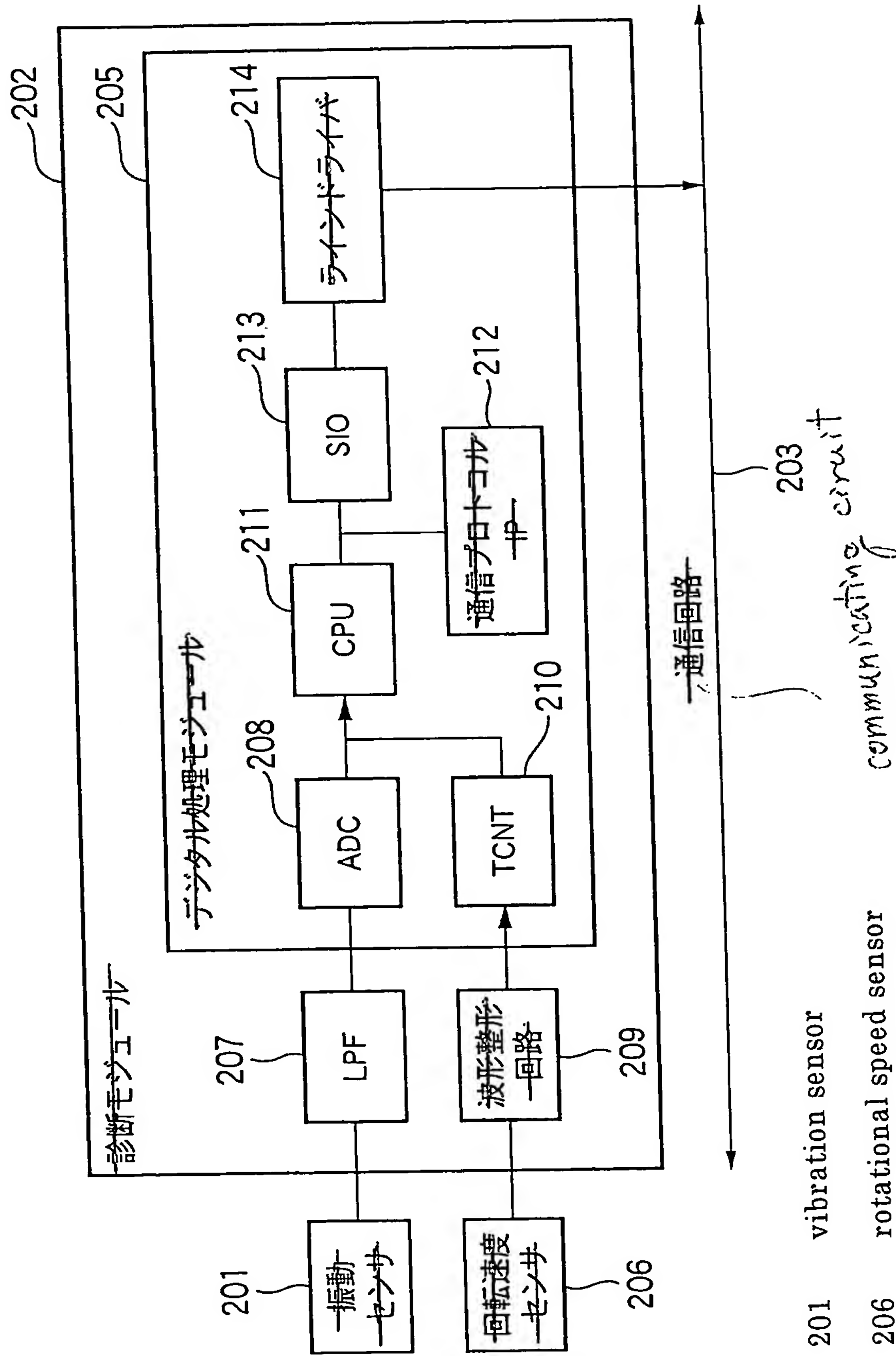


[Fig. 20] Fig. 20



[図21]

Fig. 21



- 201 vibration sensor
- 206 rotational speed sensor
- 202 diagnosing module
- 205 digital processing module
- 209 waveform shaping circuit
- 214 line driver
- 212 communication protocol IP
- communicating circuit

[Fig. 22]

S500 A/D conversion
S503 form absolute value
S504 hold to exceed threshold, time constant τ
S505 event count (count of times of exceeding threshold)
S506 coincide with wheel rotational number?
S507 internal output "F"
S508 external output "G"
S501 rotational speed changed by 15 % or more?
S502 internal output "N"
S509 output "F" by internal output consecutively by 3 times or more, or output "F" by 6 times or more in 10 times
S510 external output "Flat"
S511 external output "Good"

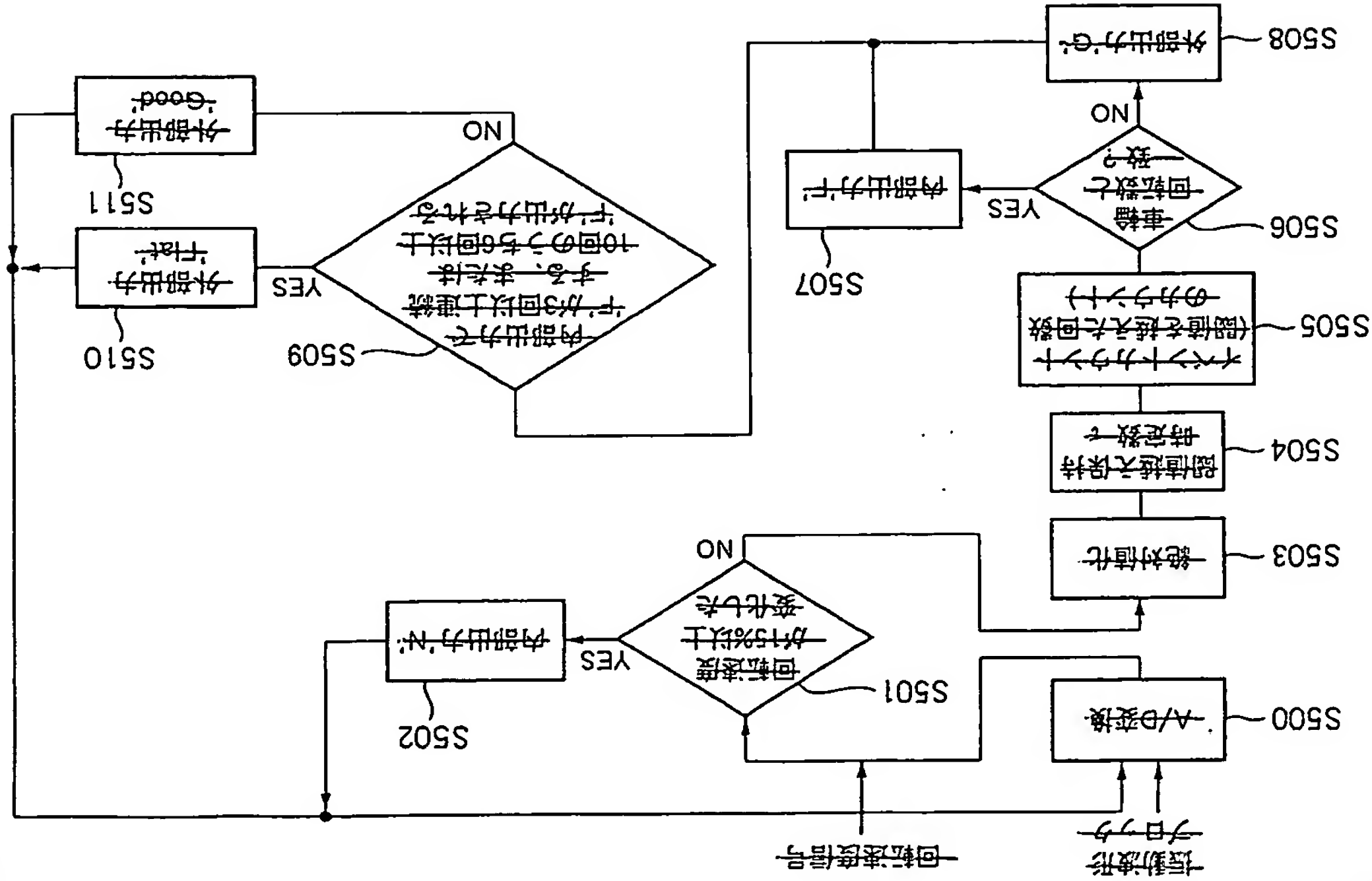


Fig. 22

Fig. 23A

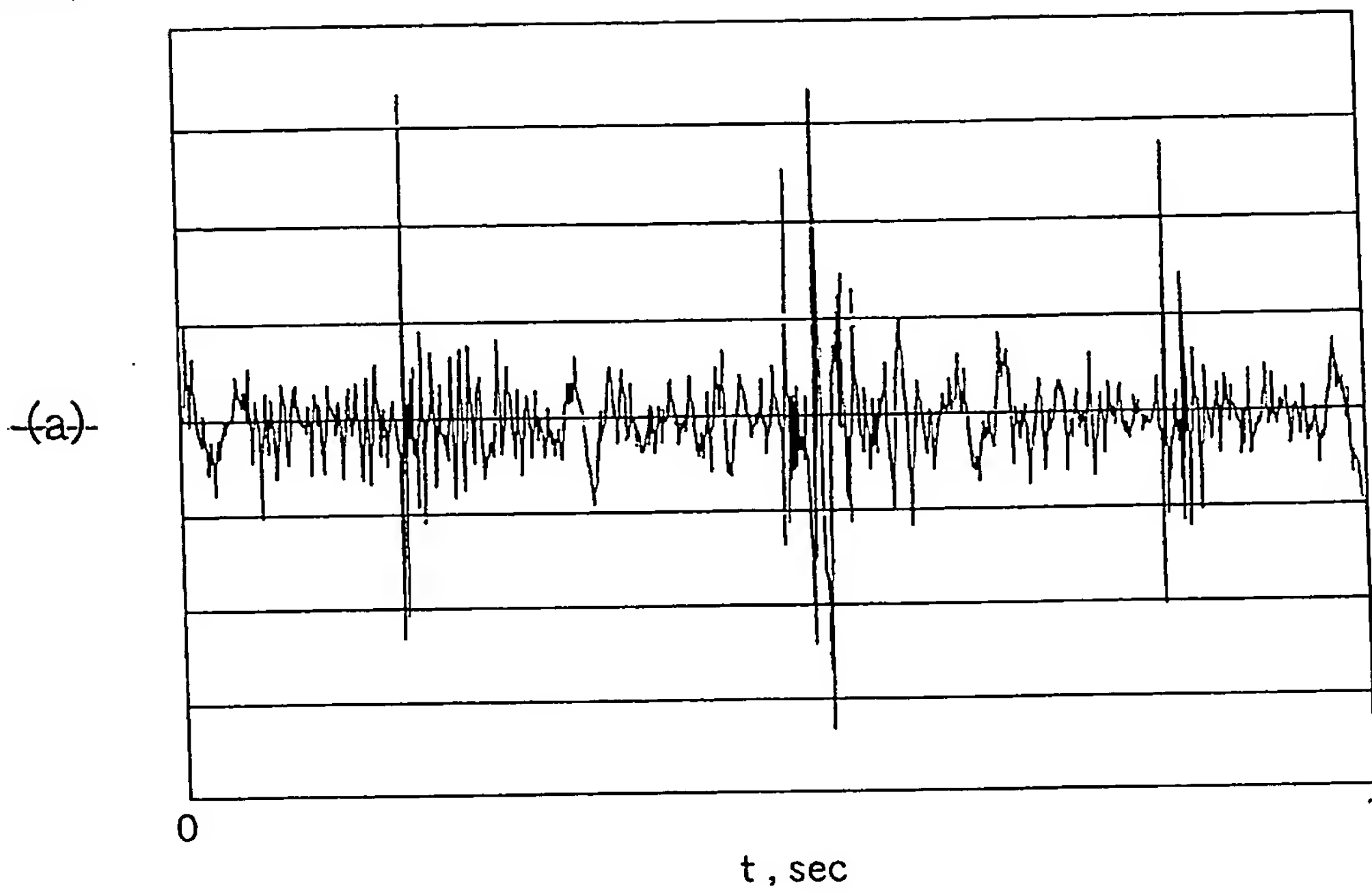
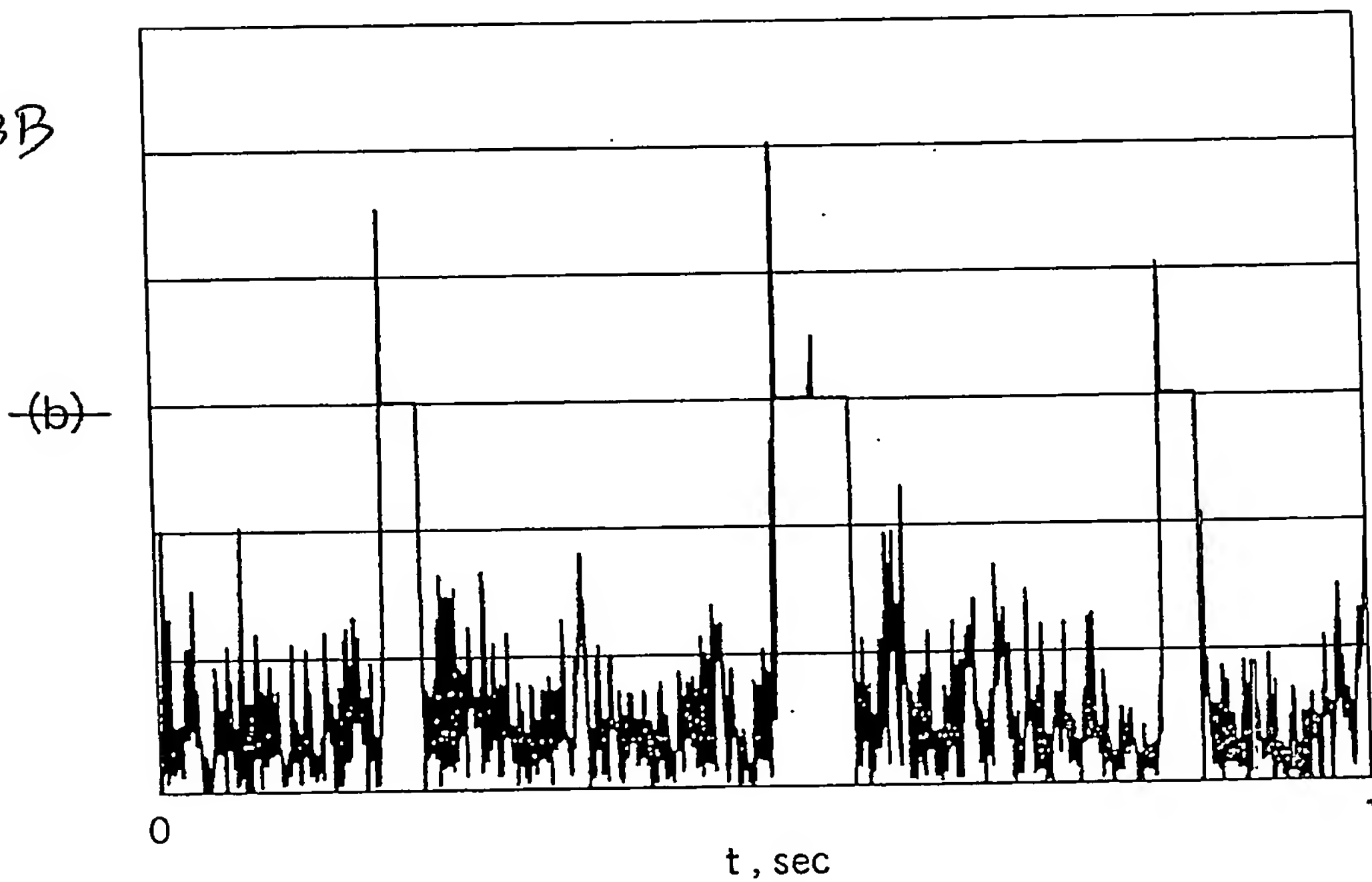
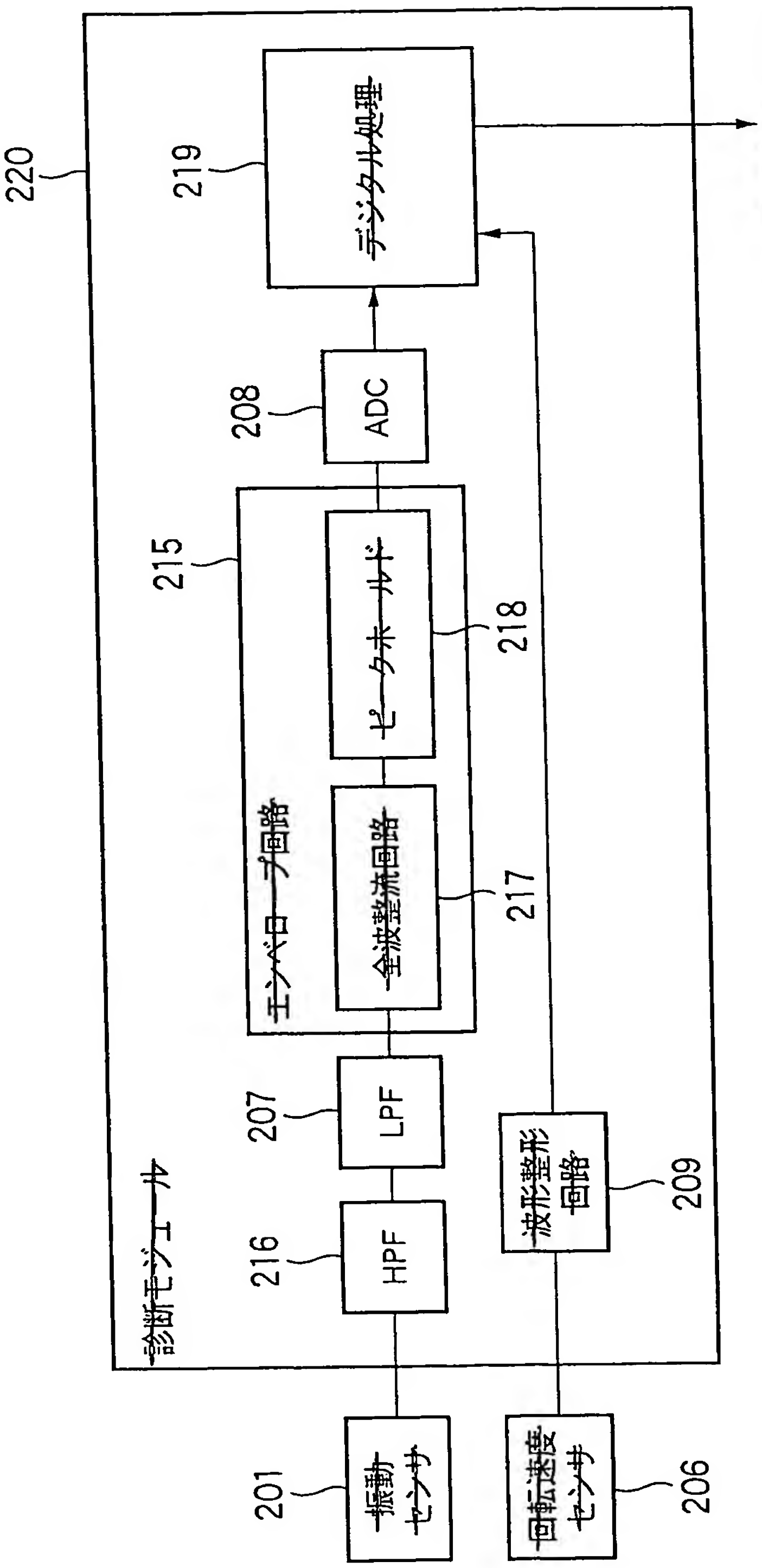
[~~23~~]

Fig. 23B

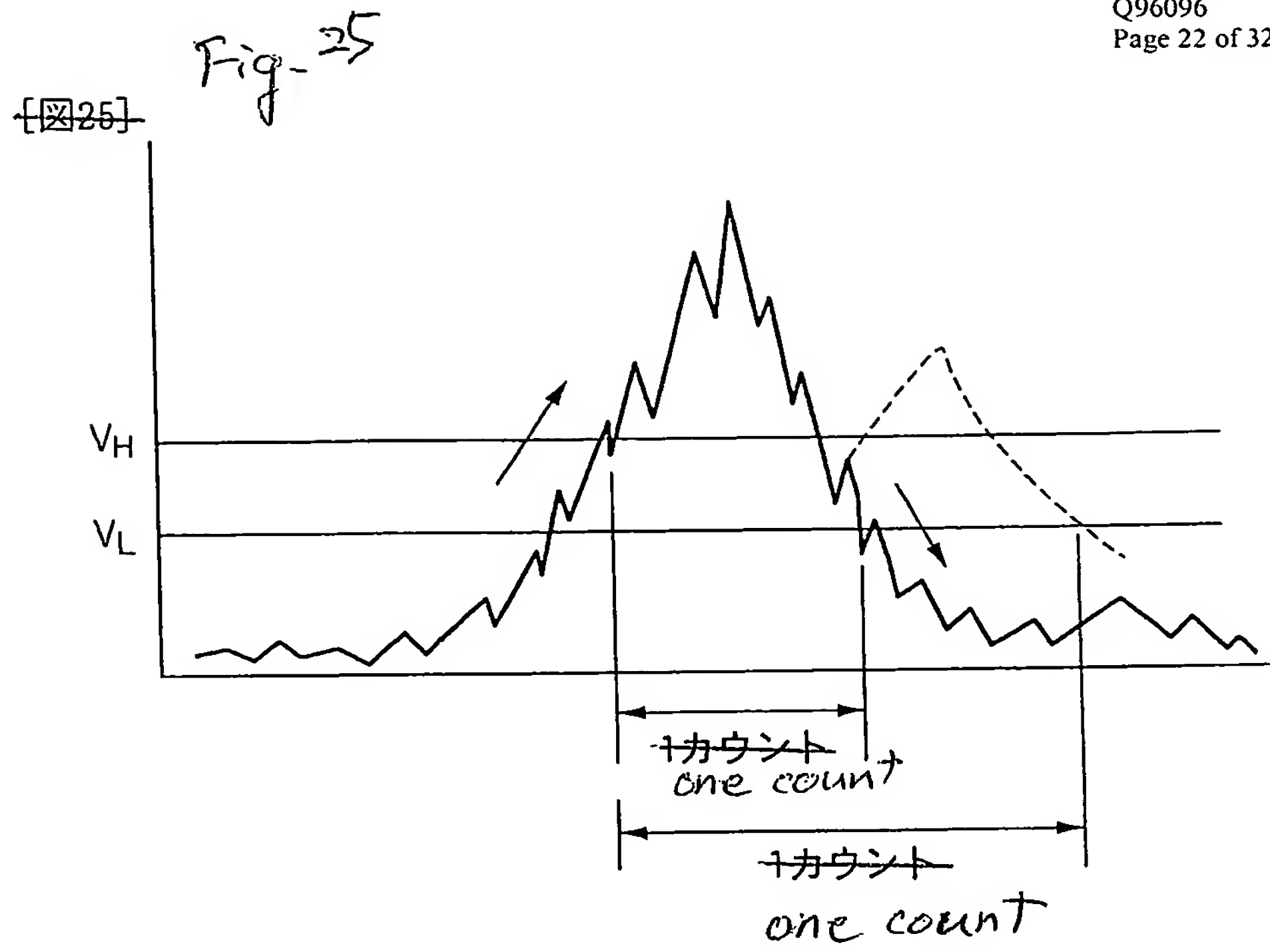


[図24]
Fig. 24



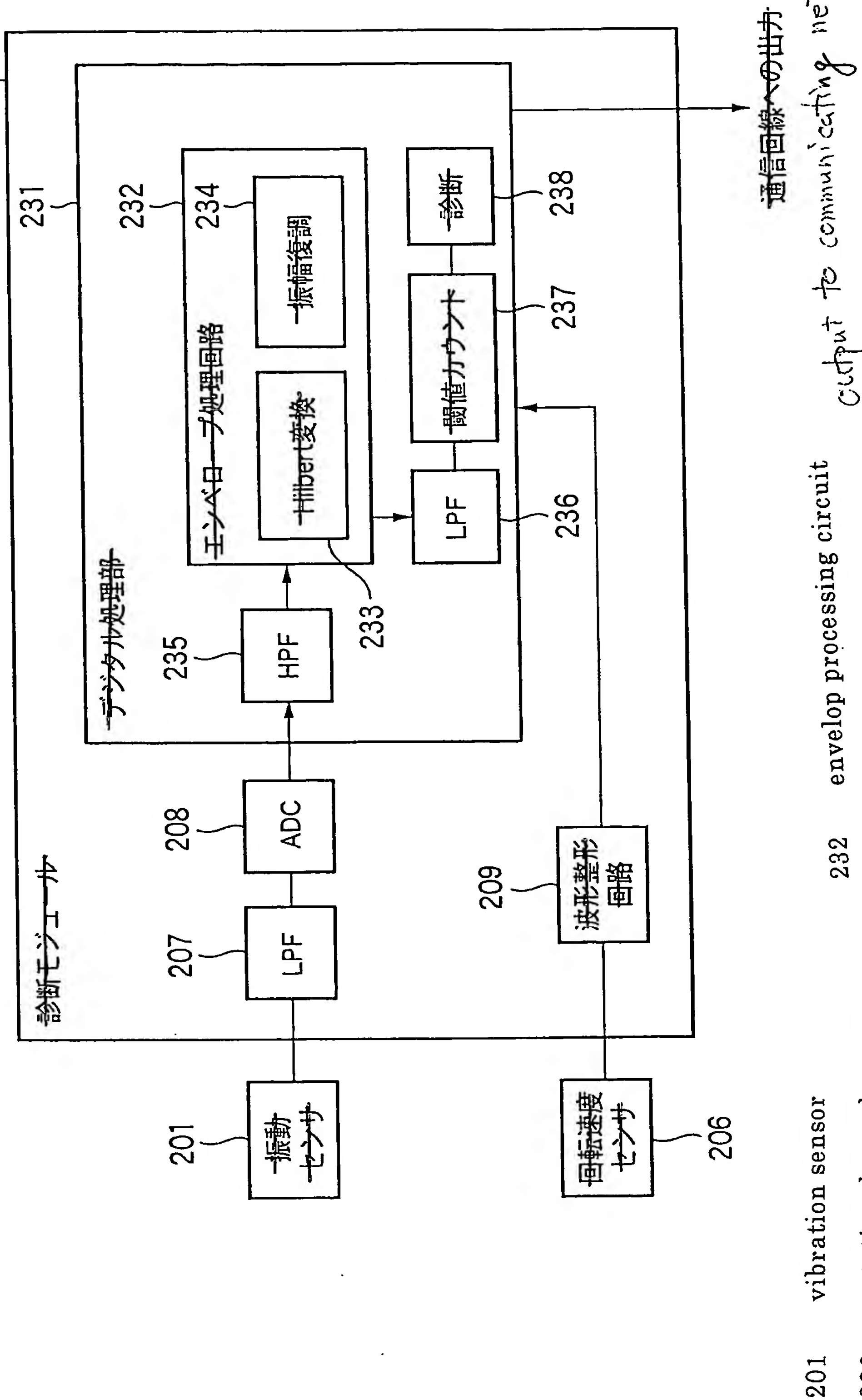
通信回線への出力
output to communicating network

- 201 vibration sensor
- 206 rotational speed sensor
- 220 diagnosing module
- 209 waveform shaping circuit
- 215 envelope circuit
- 217 full wave rectified circuit
- 218 peak hold
- 219 digital processing



[図26]

Fig. 26



201 vibration sensor
 206 rotational speed sensor
 209 waveform shaping circuit
 230 diagnosing module
 231 digital processing portion

232 envelop processing circuit
 233 Hilbert conversion
 234 decode amplitude
 237 count threshold
 238 diagnose

通信回線への出力
 output to communicating network

[図27]

Fig. 27A

(a)

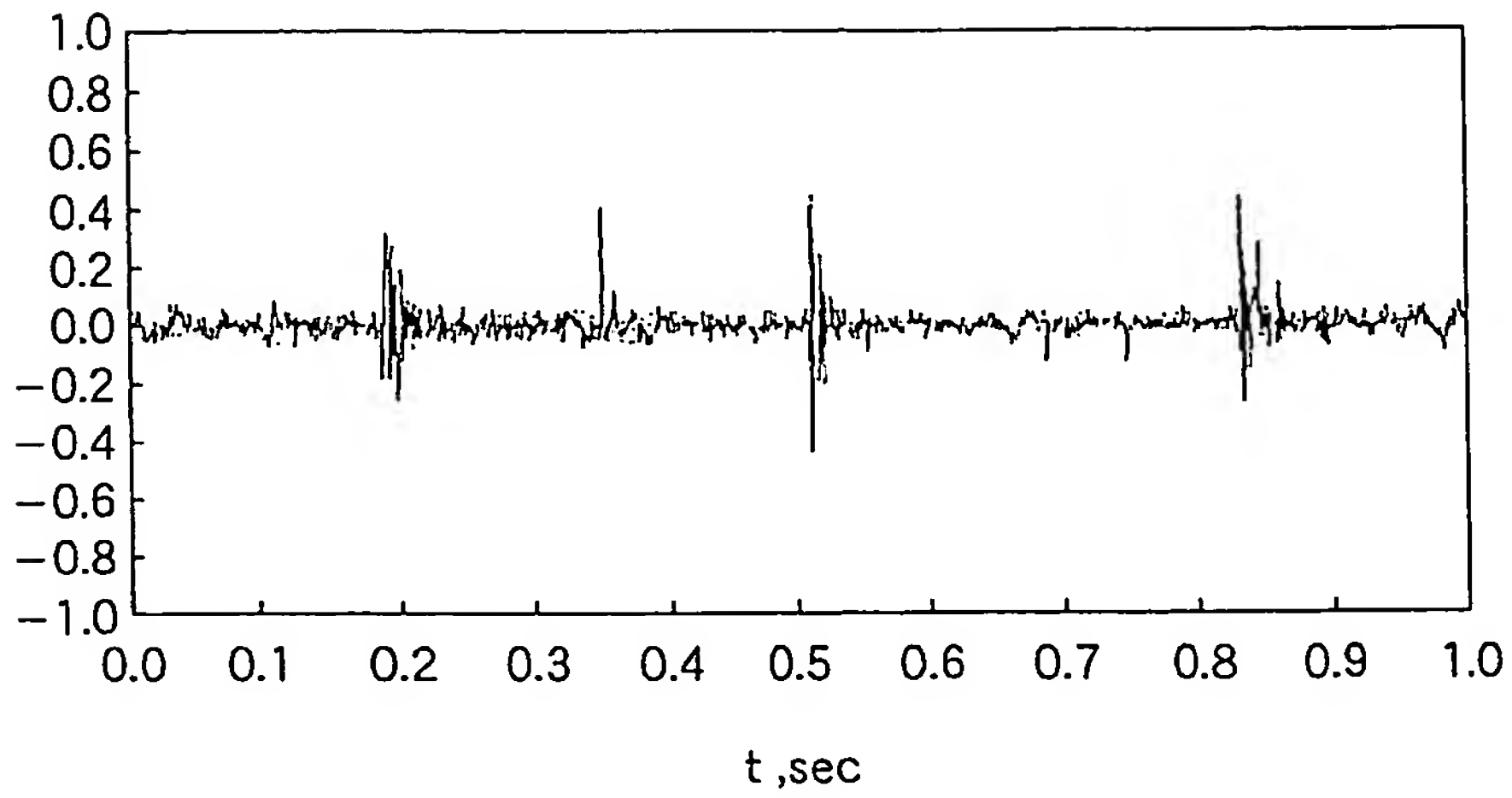
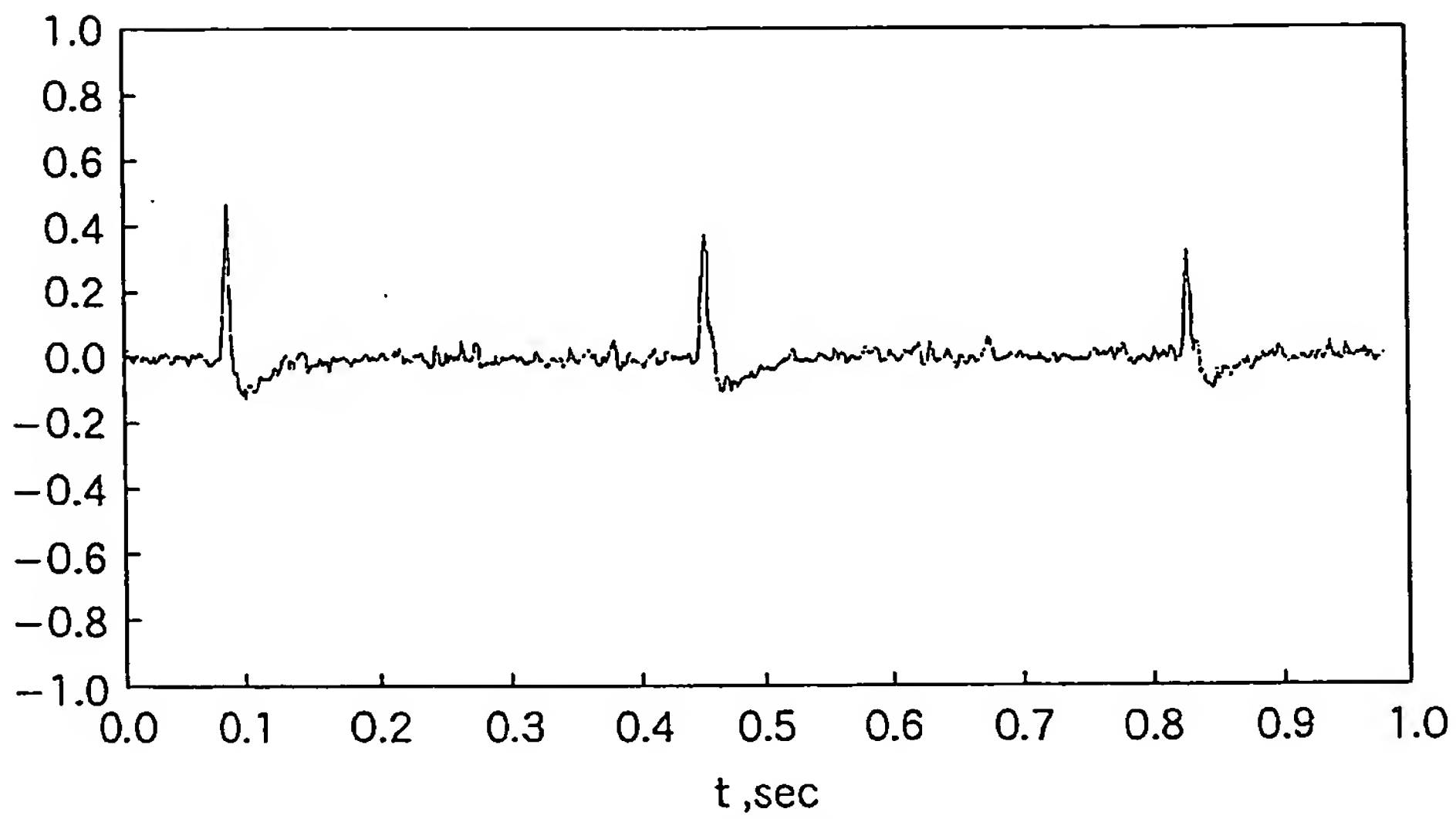


Fig. 27B

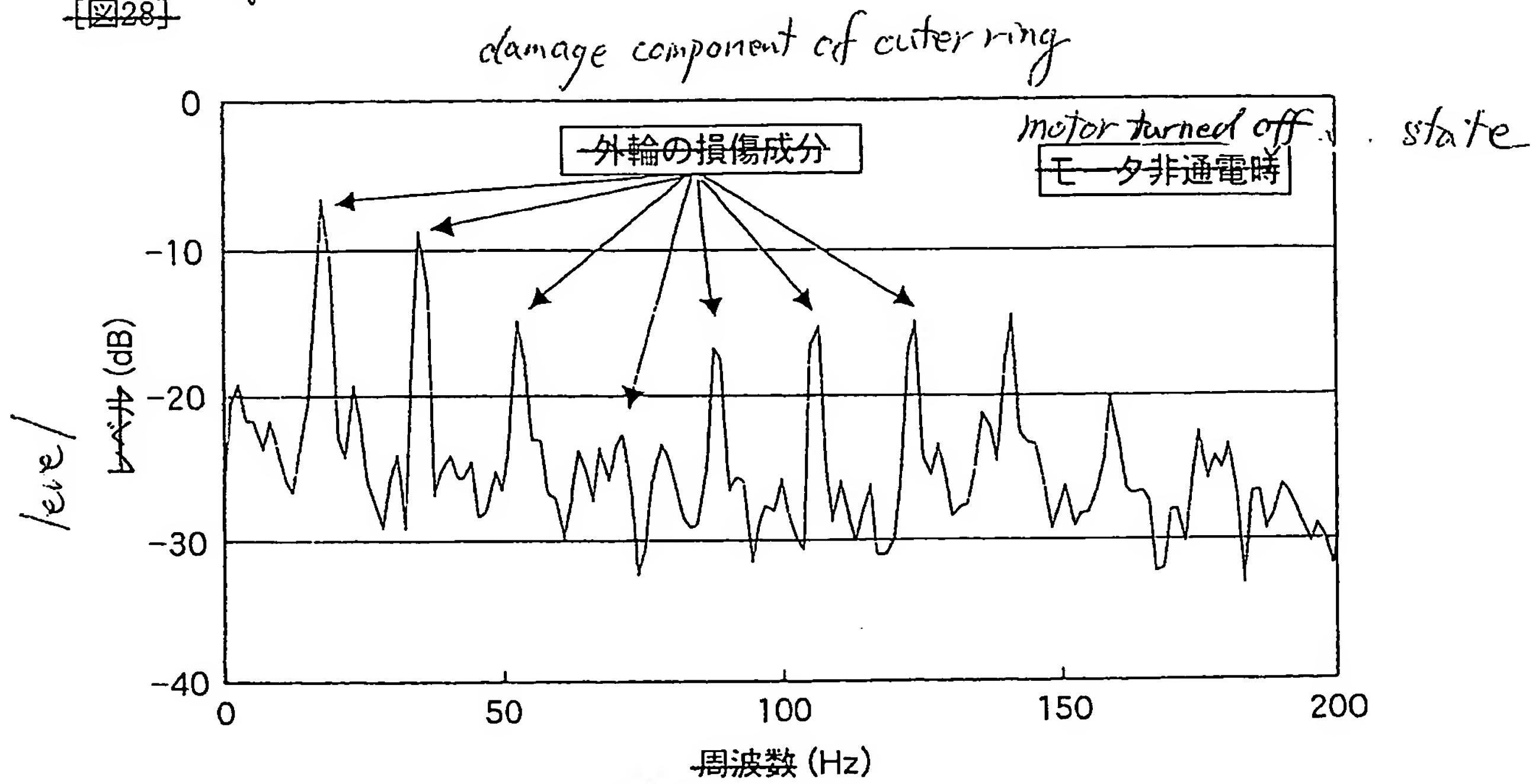
(b)



~~1秒間に3回の衝撃波が発生している~~
shock waves are generated by three times in one second.

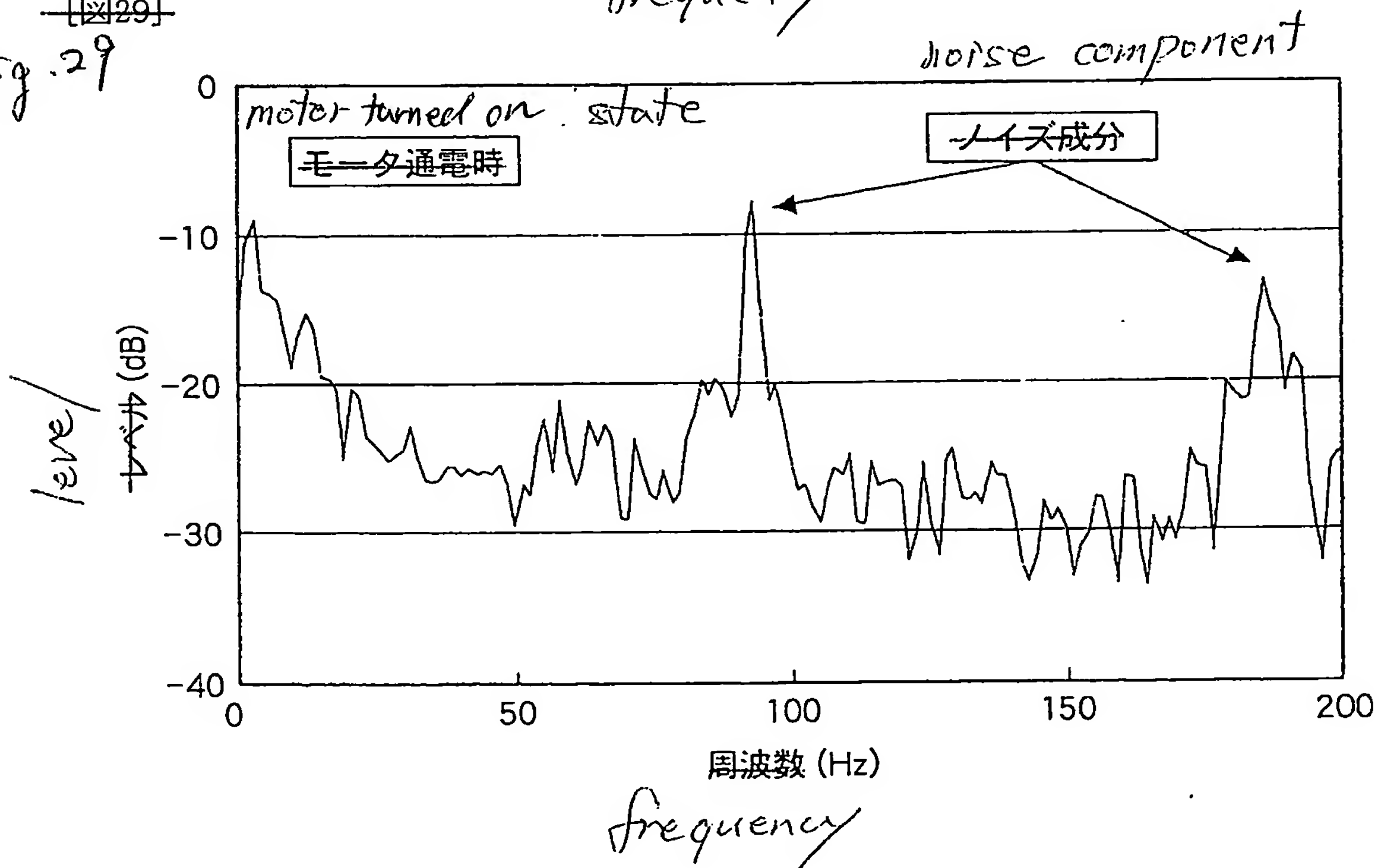
Fig. 28

[図28]



[図29]

Fig. 29



[Fig. 30]

(a)	(1) bearing rotational speed: 50 min ⁻¹
(b)	(2) bearing rotational speed: 100 min ⁻¹
(c)	(3) bearing rotational speed: 150 min ⁻¹
(d)	(4) bearing rotational speed: 300 min ⁻¹
(e)	(5) bearing rotational speed: 650 min ⁻¹
(f)	(6) bearing rotational speed: 1000 min ⁻¹
(g)	(7) bearing rotational speed: 1500 min ⁻¹
(h)	(8) bearing rotational speed: 1600 min ⁻¹

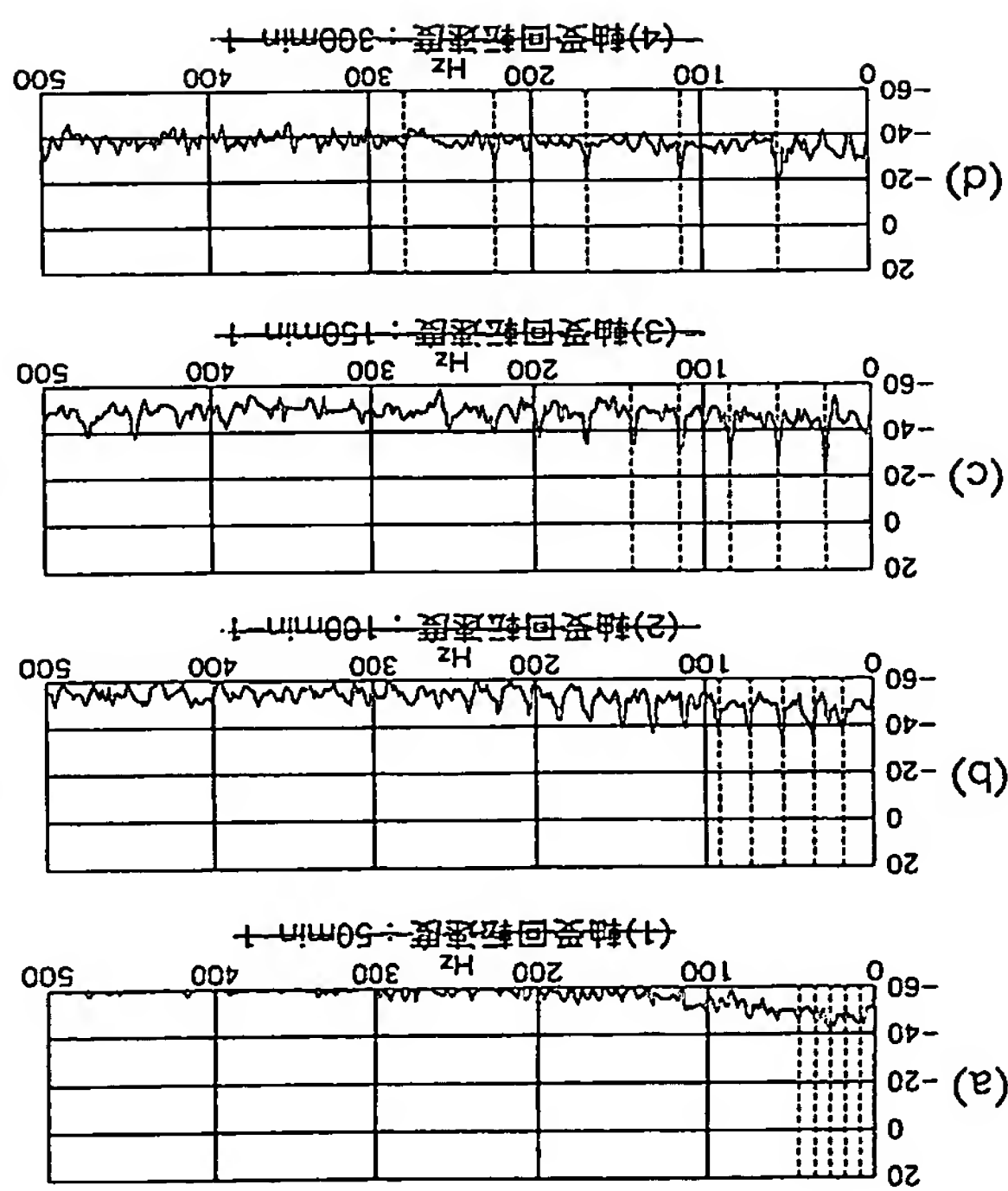
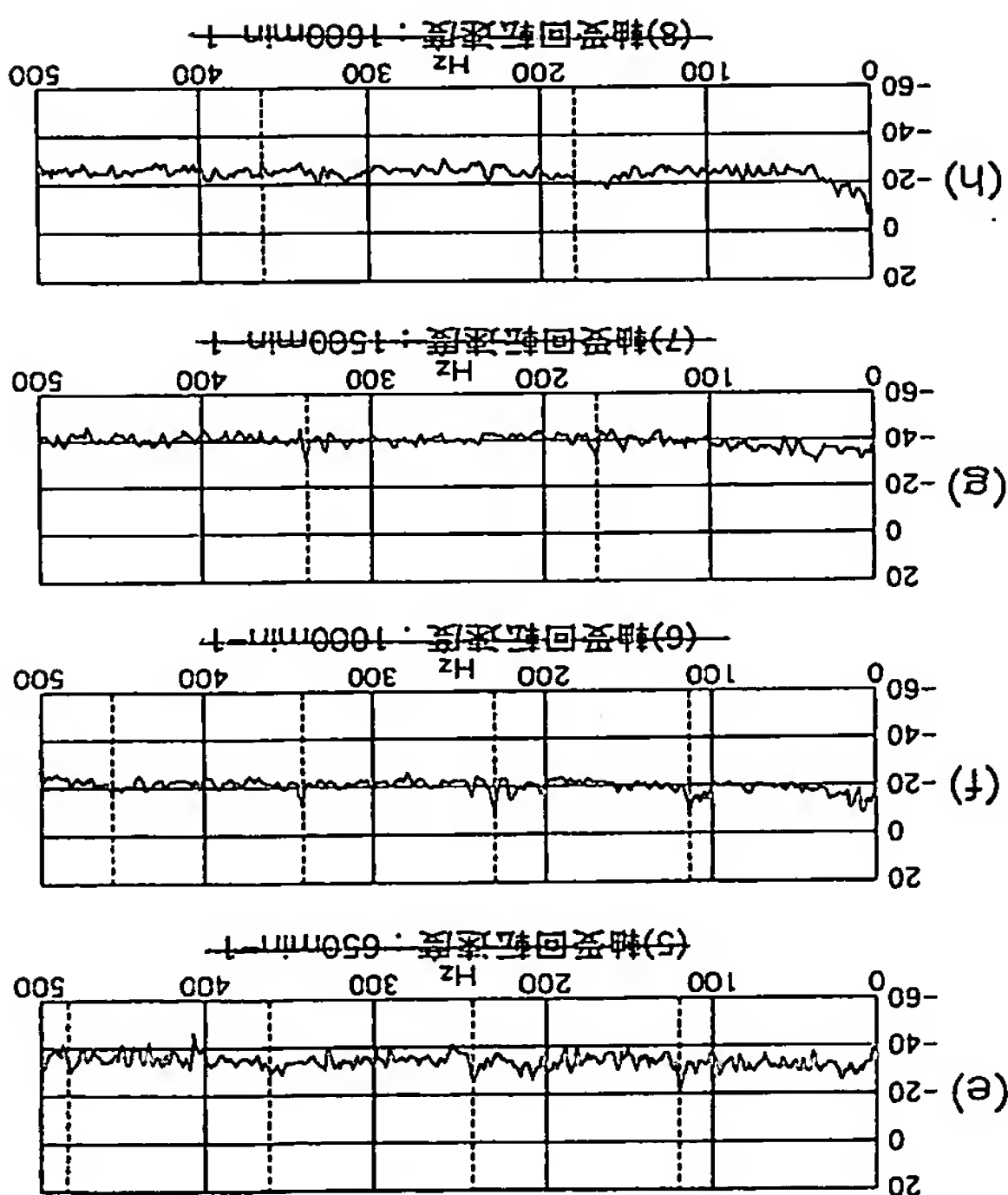


Fig. 31

[図31]

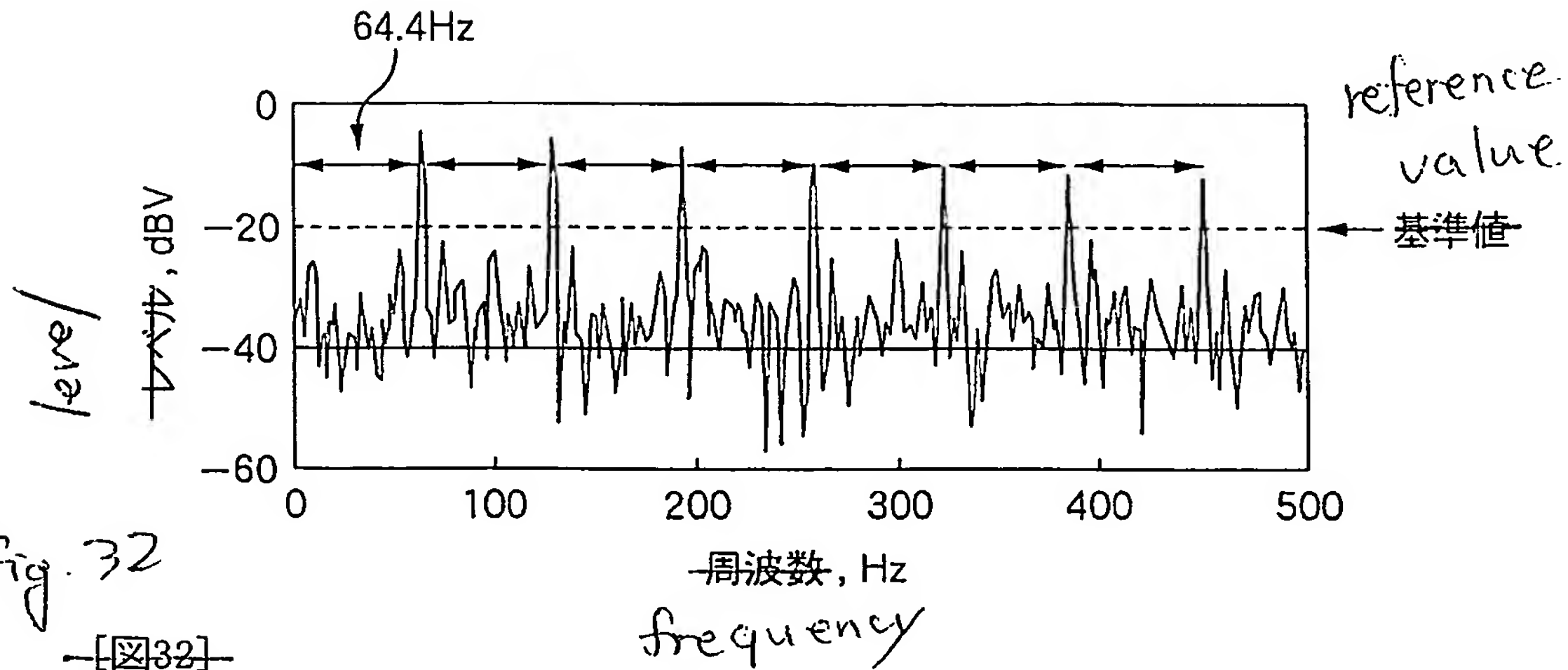


Fig. 32

[図32]

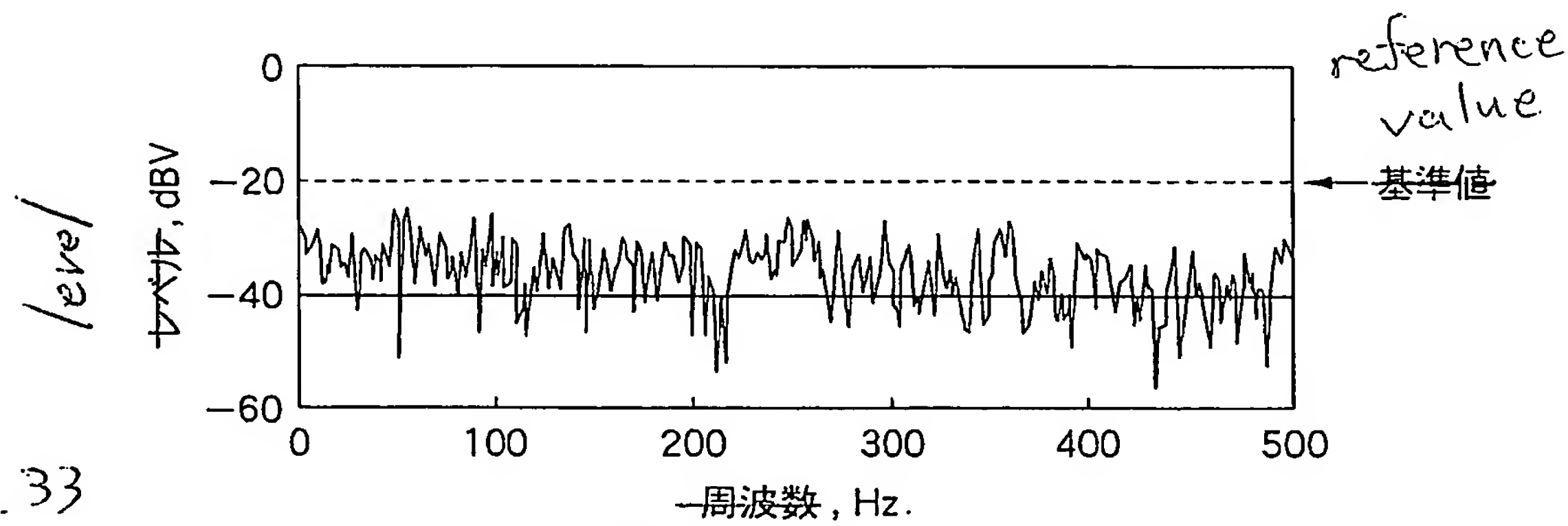


Fig. 33

[図33]

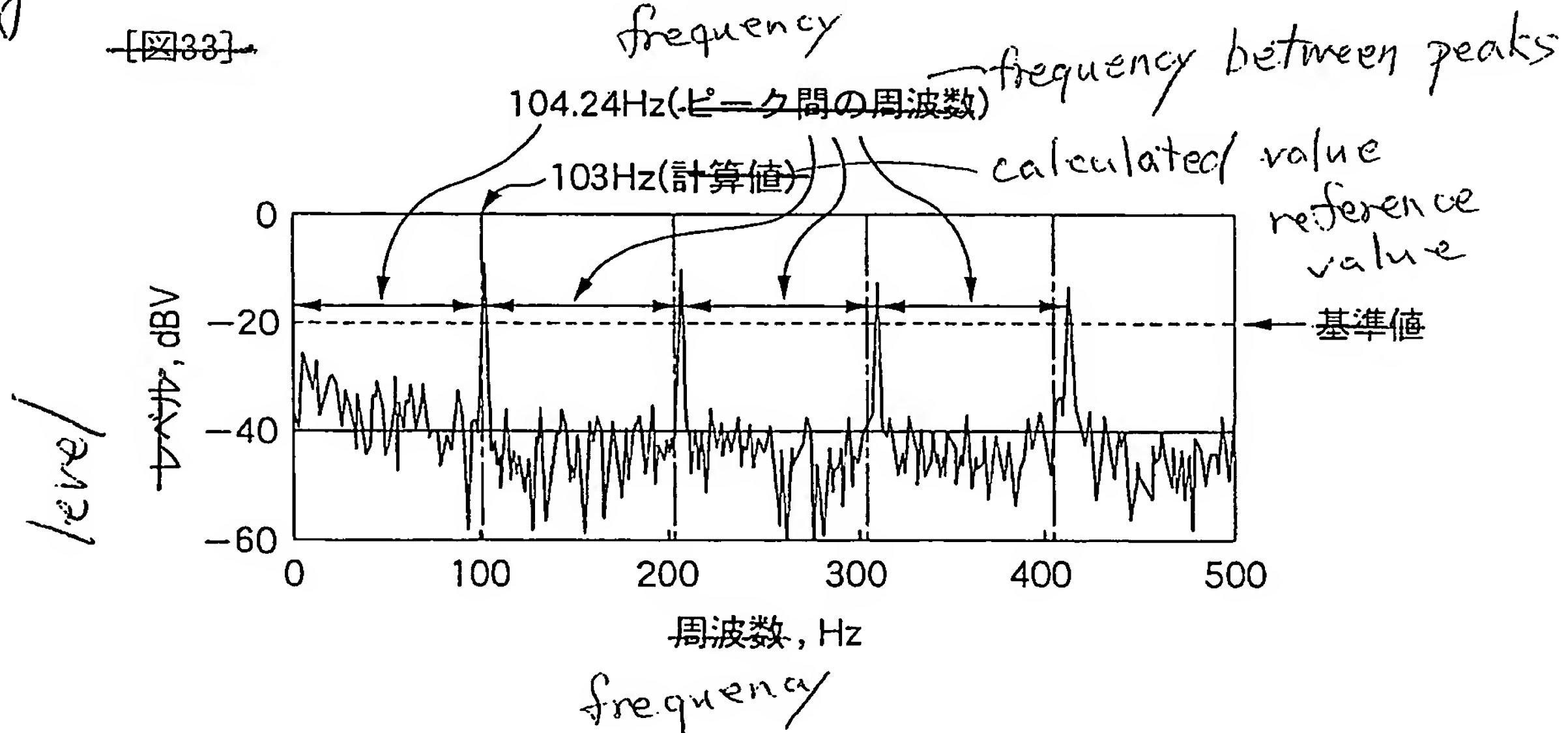
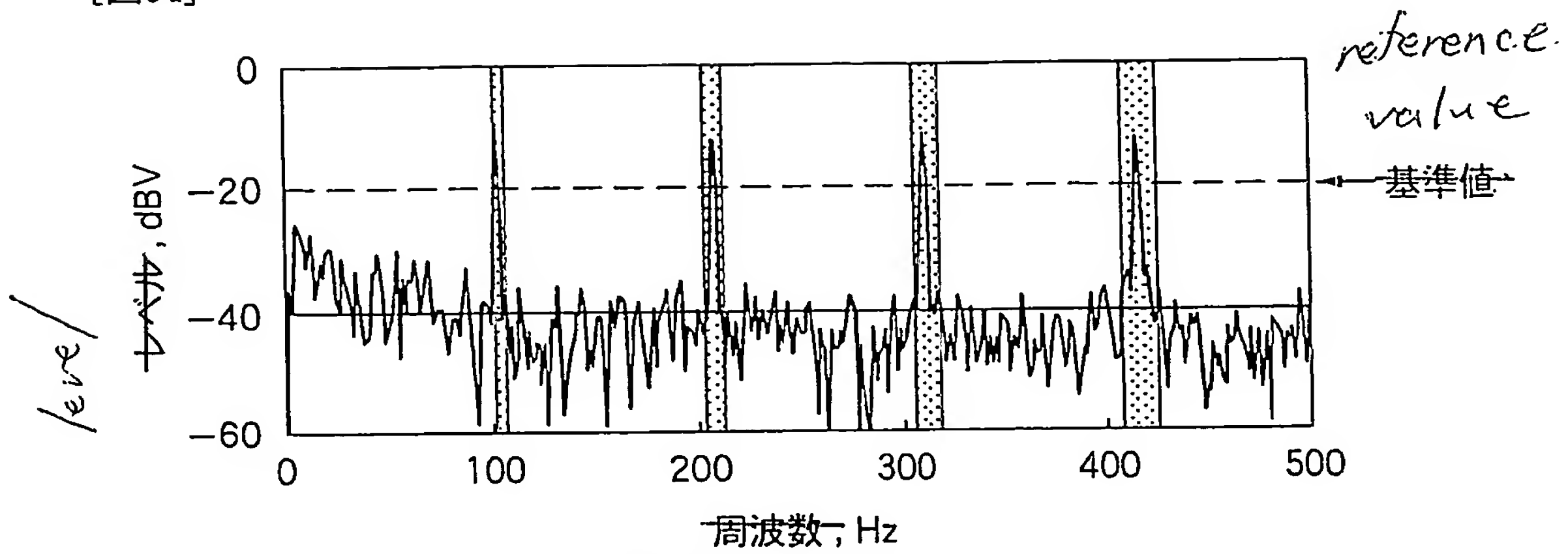


Fig. 34

[図34]



[図35] Fig. 35

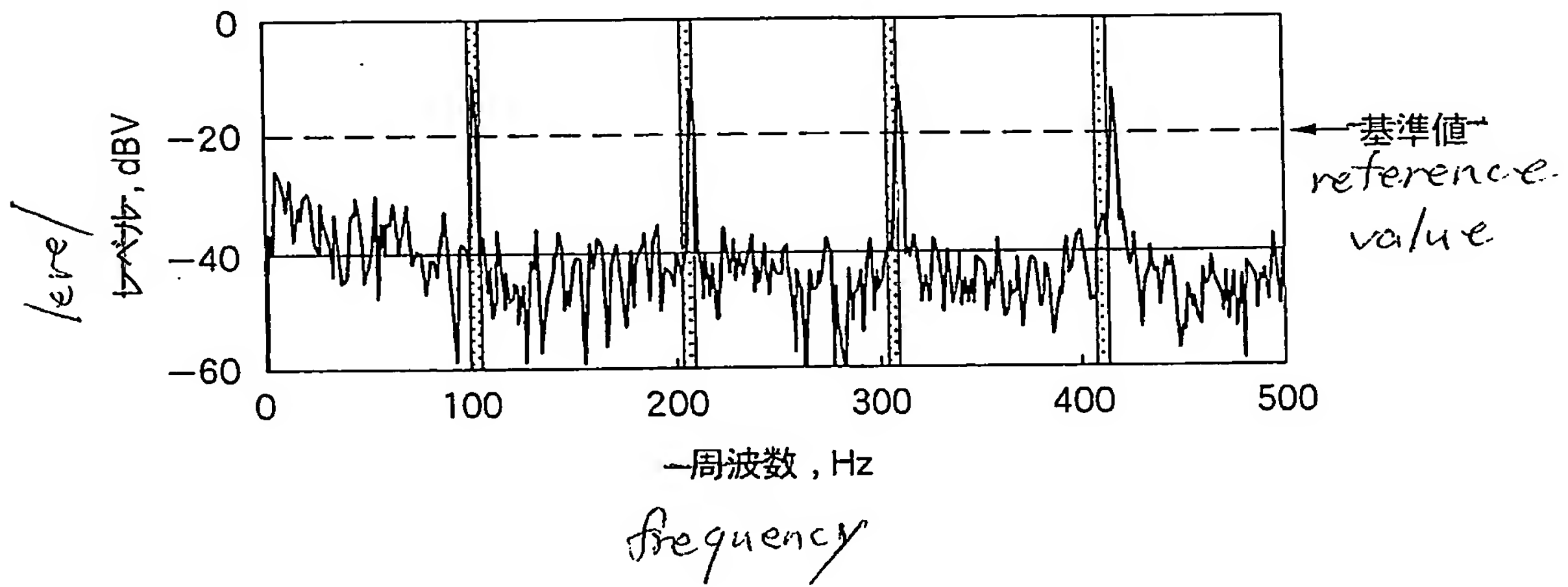
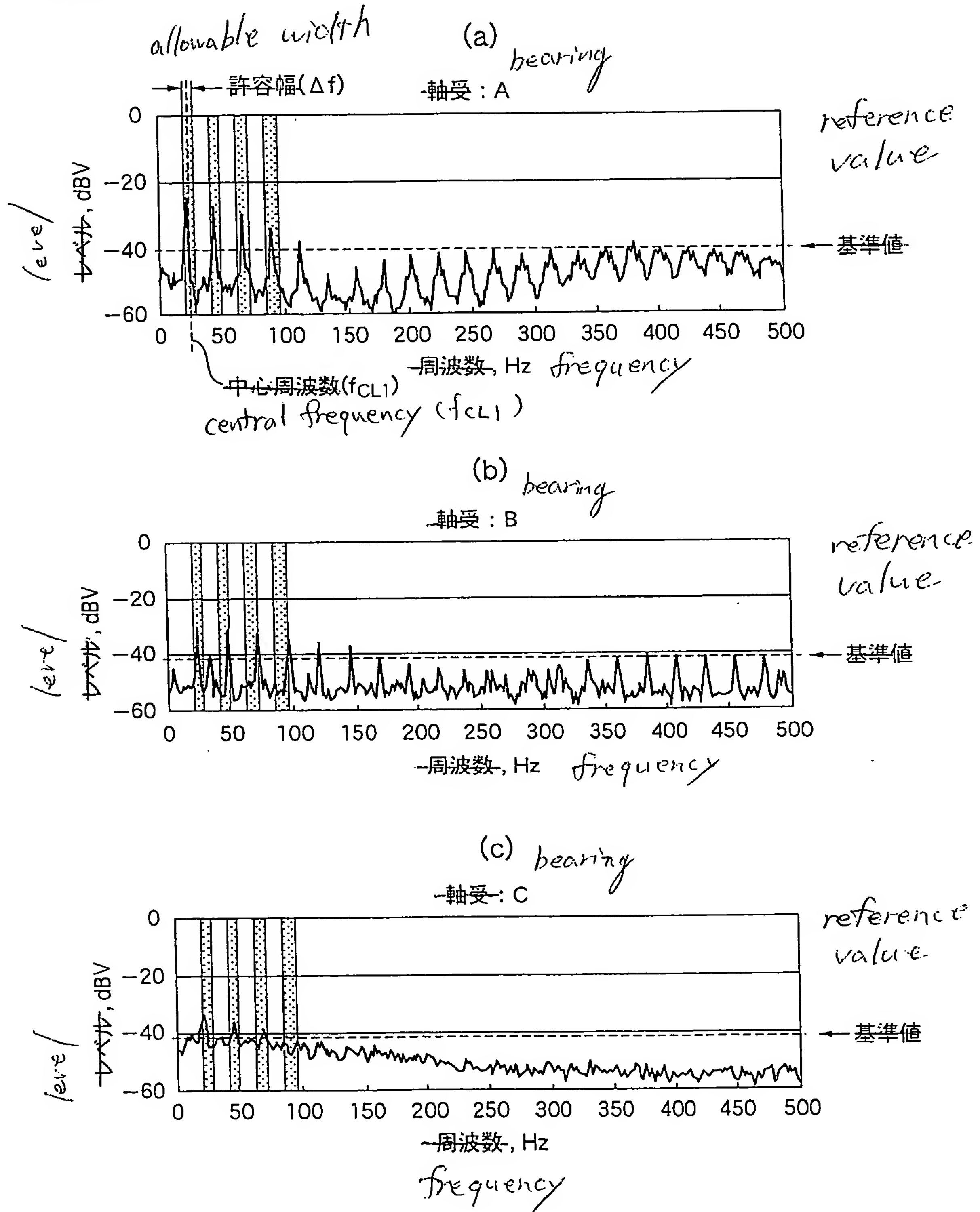


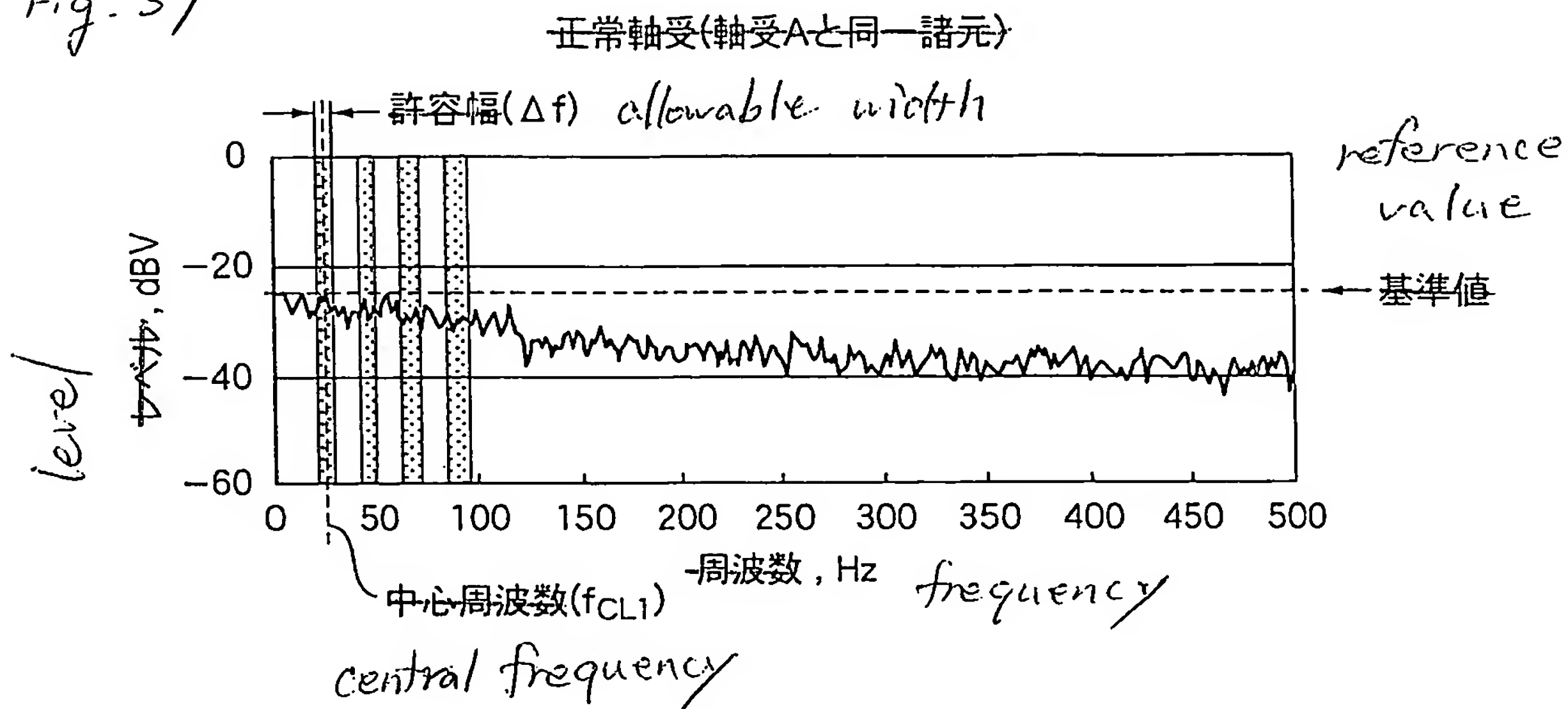
Fig. 36

[図36]



normal bearing
 (same specifications as bearing A)

[図37]
 Fig. 37



[図38] Fig. 38

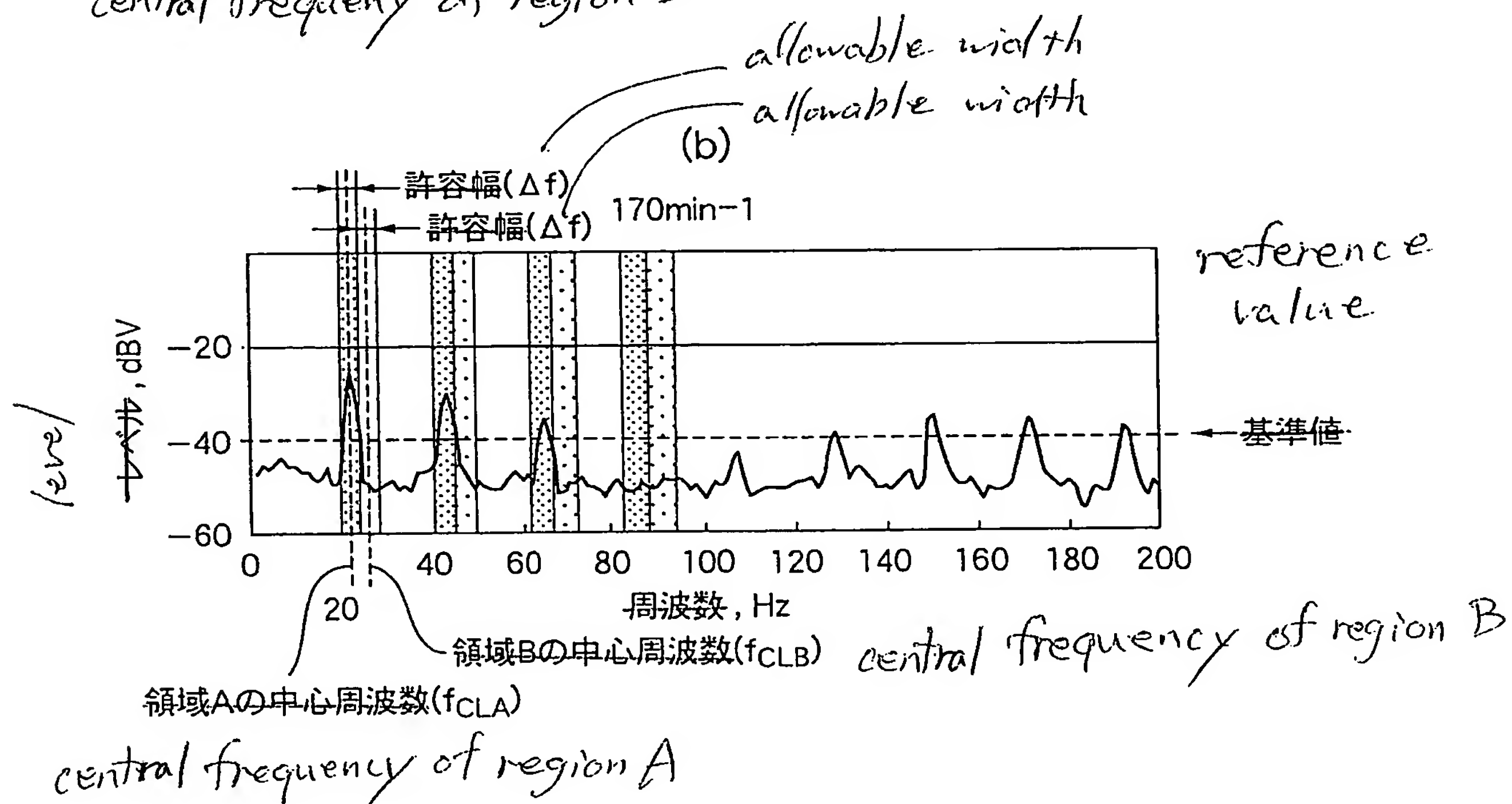
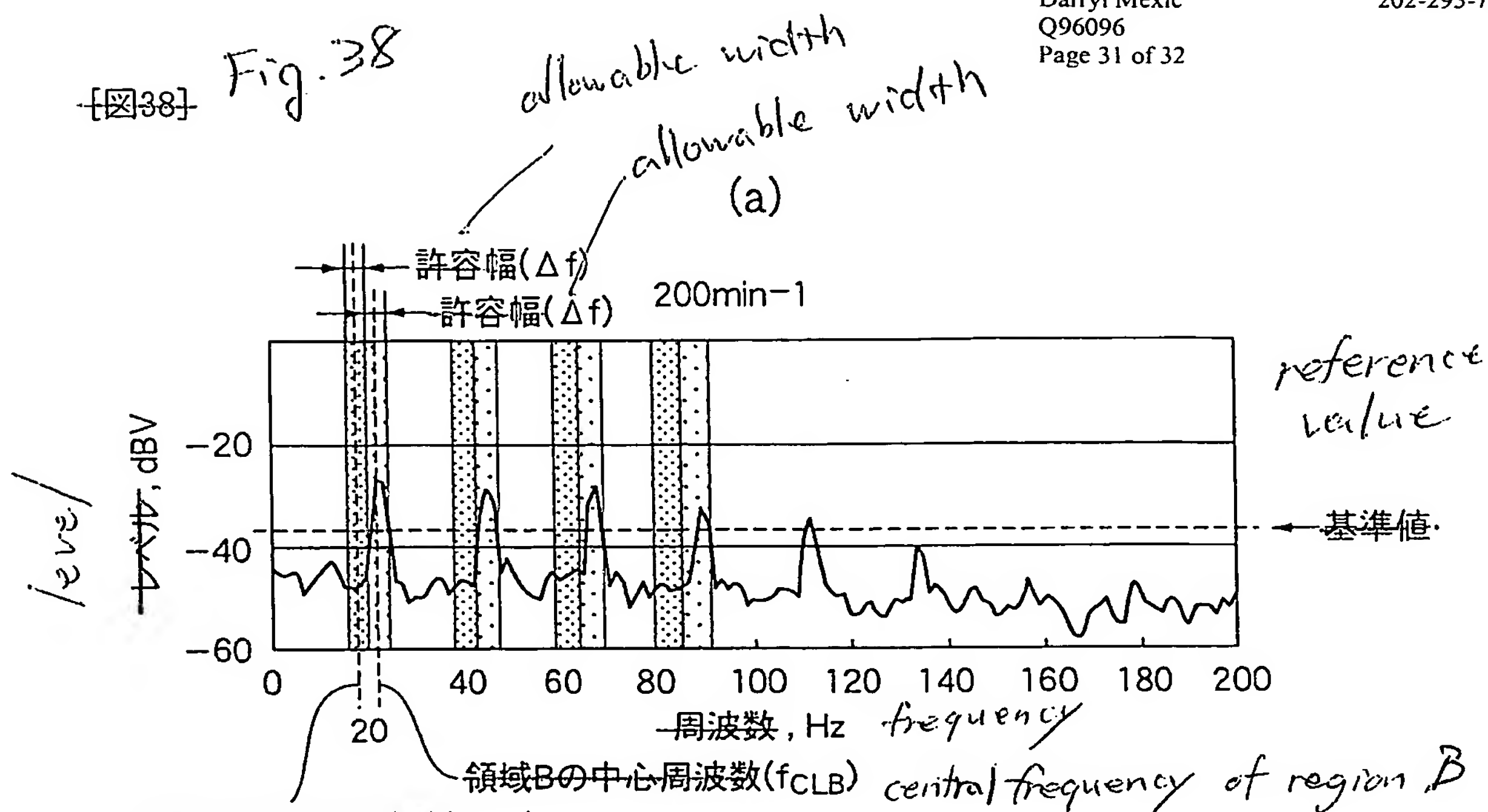


Fig. 39

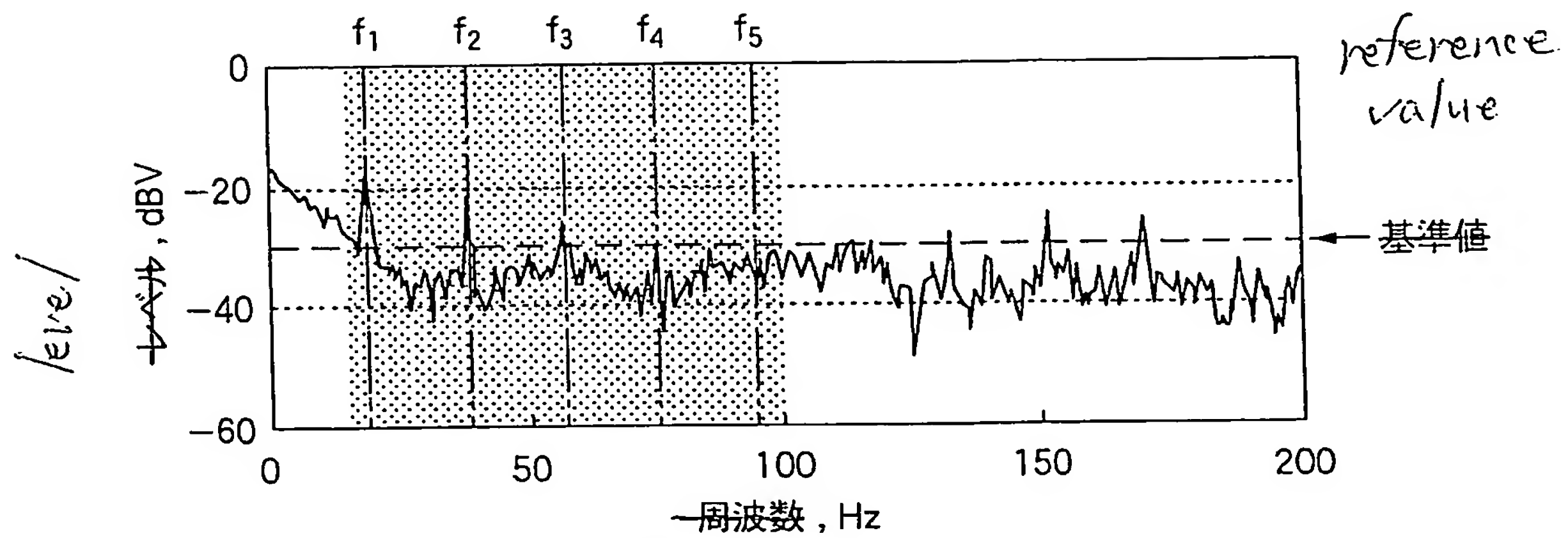


Fig. 40

